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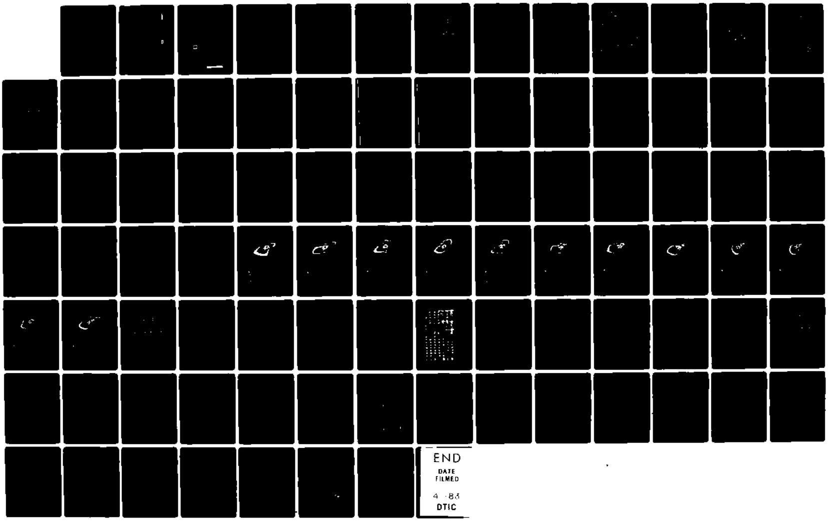

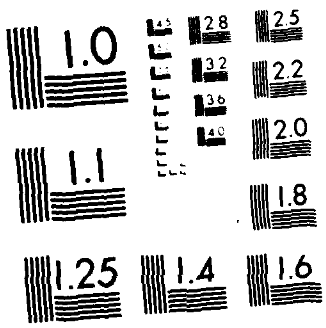


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# TERMINAL FORECAST REFERENCE NOTEBOOK

FOR

RAF FAIRFORD, UNITED KINGDOM



PUBLISHED BY
DETACHMENT 18
28TH WEATHER SQUADRON
2D WEATHER WING (MAC)
UNITED STATES AIR FORCE
3 JANUARY 1983

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# SECTION I

# LOCATION AND TOPOGRAPHY

## LOCATION AND TOPOGRAPHY

(FIG 1 , 2 )

RAF Fairford is located in the Upper Thames Valley at 51°41°N, 01°47°W. The station elevation is 268 feet (87M).

There is an abundance of moisture sources surrounding the airfield. One mile south is the Thames River, with the eastern end of the runway only a few feet above river level. North-Northwest to east, starting one mile to the north to 2 miles in the east, is a series of quarry lakes.

Fairford is situated at the foot of the Cotswold Hills, which extend from the WSW to the NNE rising to an elevation of 1000 feet (300M) 17 miles to the NW. Twelve to fifteen miles south to southeast the Marlborough Downs and the White Horse Hills reach a height of approximately 900 feet (270M). In closer to the south and southeast, about five miles, a minor line of hills reach approximately 450 feet (140M). At the end of the valley thirty miles to the SW the Mendips cap the valley formed by the Cotswolds and Marborough Downs Hills. The Mendips rise to 1000 feet (300M). Ninety miles to the W-NW the Welsh Mountains, reaching 2,000 - 3,000 feet, give some shelter from systems approaching from that direction. The most exposed approach to the base is from the NE with a gradual upslope from the North Sea to Fairford. To a lesser extent the SW is exposed to the Bristol Channel thru valleys around the Mendips.

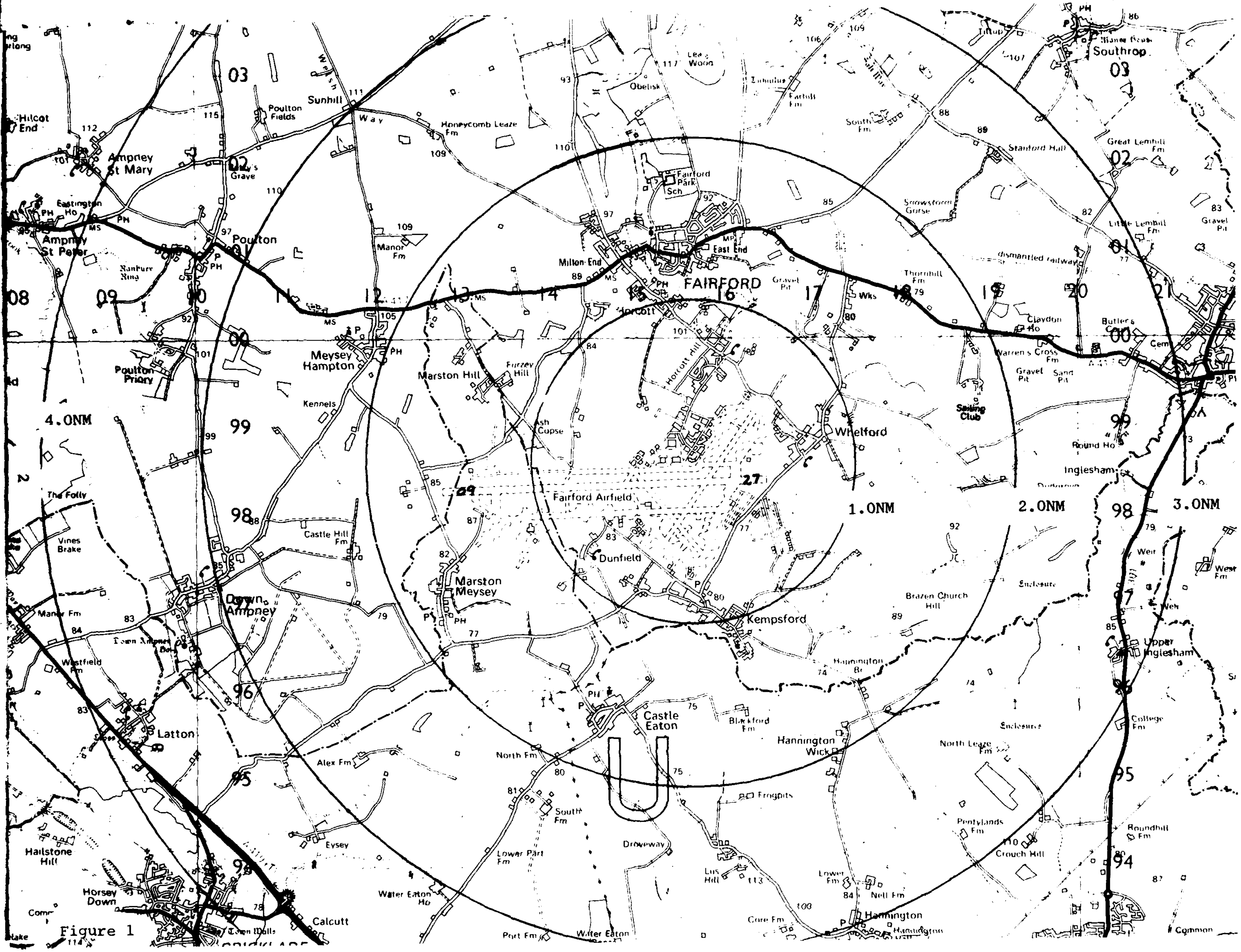
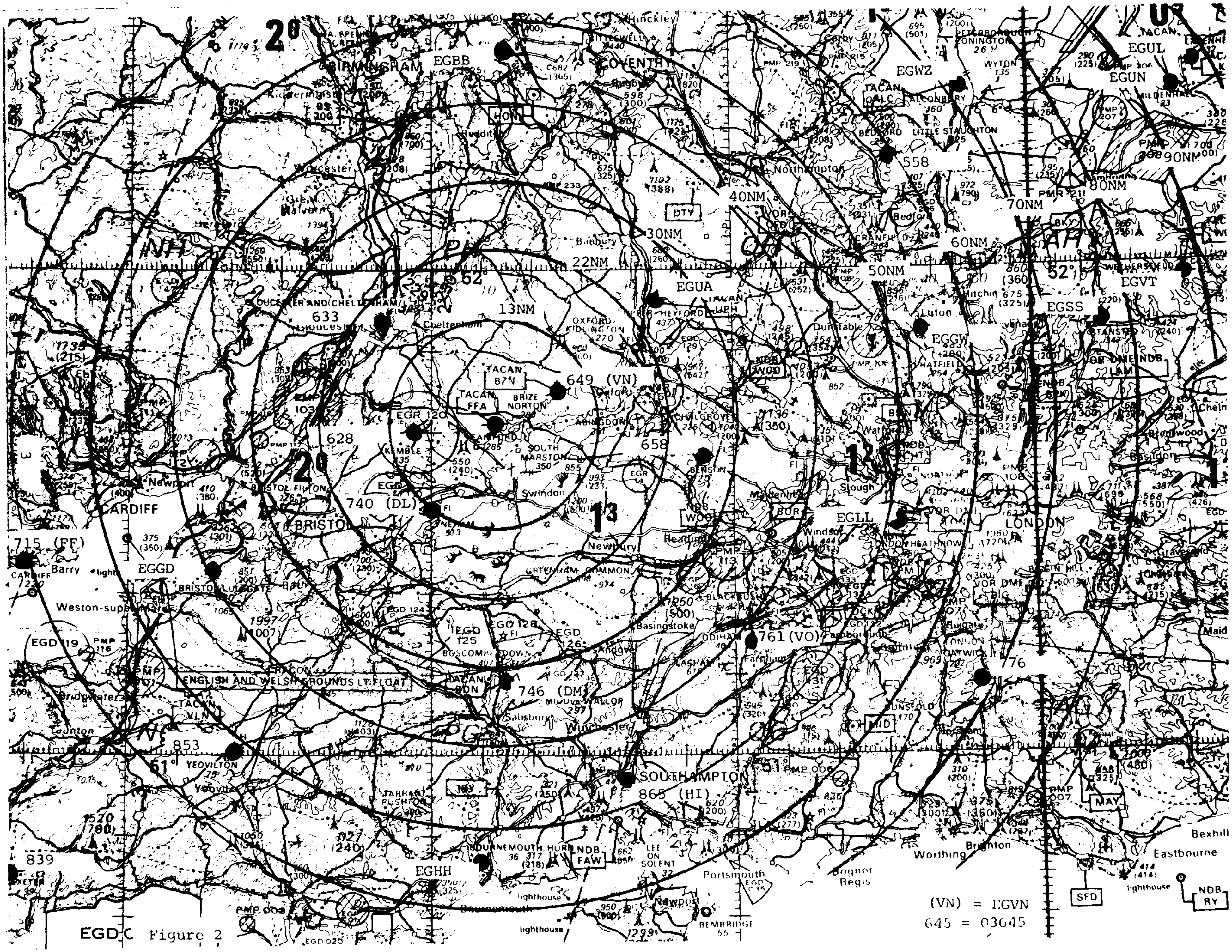

FAIRFORD
Fairford Airfield
1.0NM
2.0NM
3.0NM
4.0NM
Kempsford
Whelford
Dunfield
Marston Meysey
Castle Eaton
Meysey Hampton
Marston Hill
Horcott
Milton End
East End
Poulton
Down Ampney
Latton
Ampney St Mary
Ampney St Peter
Sunhill
Southrop
Upper Inglesham
Inglesham
Hannington
Hannington Wick
Calcutt
Horsey Down
Hailstone Hill
Hilcot End
Poulton Priory
Poulton Fields
Fairford Park
Sailing Club
dismantled railway

Figure 1



(VN) = EGVN
645 = 03645
13NM
22NM
30NM
40NM
50NM
60NM
70NM
80NM
90NM
649 (VN)
658
628
633
740 (DL)
715 (FF)
746 (DM)
761 (VO)
776
853
865 (HI)
839
558
EGBB
EGUA
EGGW
EGSS
EGLL
EGGD
EGHH
EGWZ
EGUL
EGUN
EGVT
BIRMINGHAM
COVENTRY
Northampton
Bedford
Luton
Oxford
Swindon
Cheltenham
Gloucester
Worcester
BRISTOL
CARDIFF
Newport
Reading
Newbury
Slough
Windsor
LONDON
Basingstoke
Winchester
Salisbury
SOUTHAMPTON
Portsmouth
Worthing
Brighton
Eastbourne
Bexhill
Bognor Regis
Yeovil
Taunton
Weston-super-Mare
Barry
ENGLISH AND WELSH GROUNDS LT FLOAT

Figure 2

CLIMATIC AID BY WIND DIRECTION

(Fig 3)

a. Stratus in moist airstreams. Good visibility except for possibility of Fog in very light winds. Showers in unstable moist air.

b. Showers in unstable air, high stratus advects in off Bristol Channel. Visibility generally good. Primary wind direction.

c. Generally fair weather clouds and good visibility. Fog unusual from this direction. Cooler temperature can be expected.

d. Midlands smoke and haze in light North wind may reduce visibility to 2-3 NM.

e. Exposed to North Sea stratus, bases sometimes below 400 ft with NE-E winds. North Sea stratus usually above 600 ft during late spring and summer.

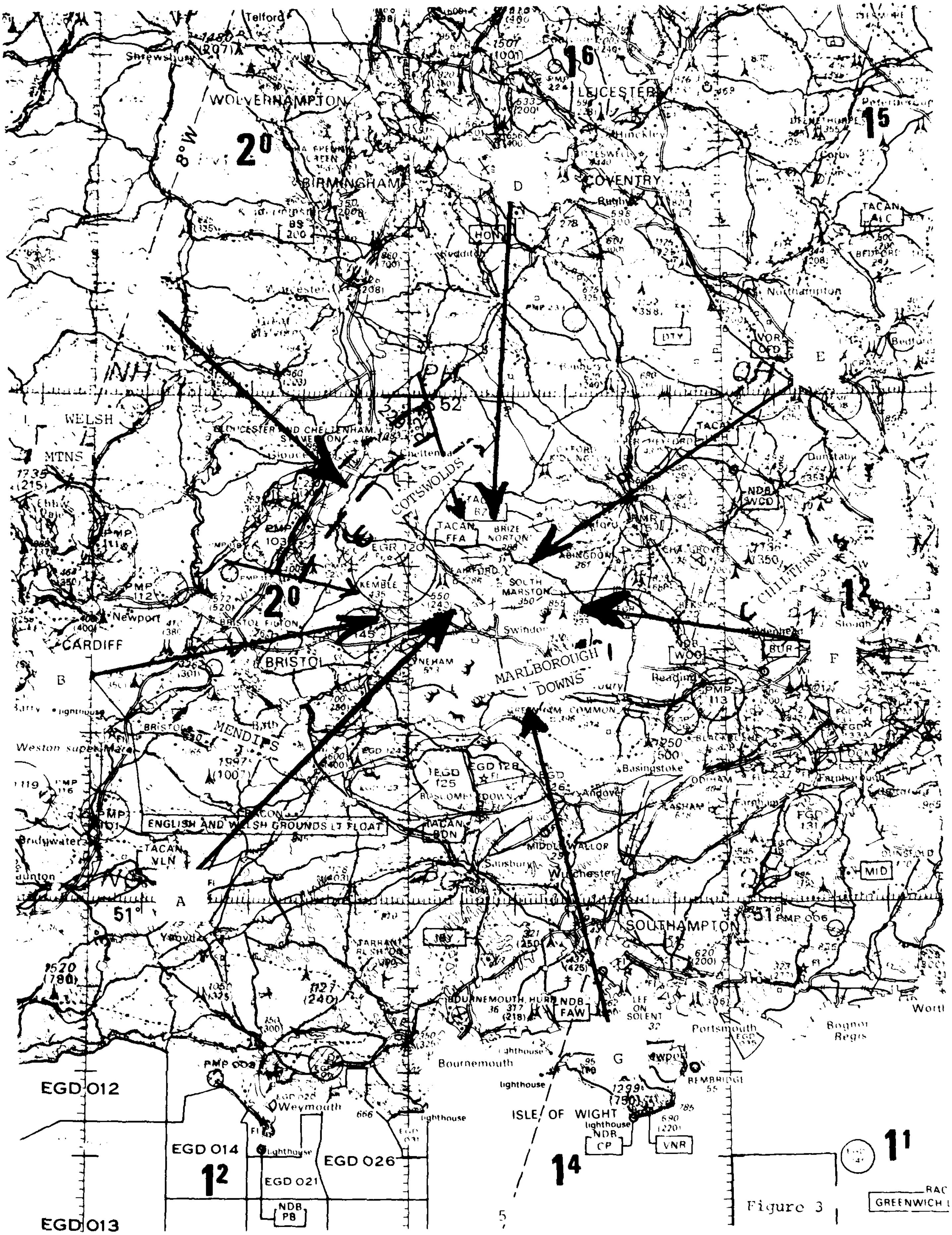
1. Radiation fog is common in winter half of year. Morning clearance is regular, but sometimes delayed to noon by advection of fog and stratus into area.

2. Surface winds often approach geostrophic speed. Secondary wind direction, more common in winter and early spring.

f. Visibility may be low in haze (1 1/2 - 2 NM). Low stratus is common in winter advected up the Thames Valley.

g. Marlborough Downs give some protection from low stratus. If stratus does advect in generally around 1,000 ft.

NOTE: Located in the Forecaster's Aids Notebook are upslope/downslope conditions, by wind direction, for Great Britian.



WOLVERHAMPTON
BIRMINGHAM
LEICESTER
COVENTRY
Northampton
Bedford
WELSH
MTNS
CARDIFF
Newport
BRISTOL
COTSWOLDS
CHILTERNS
MARLBOROUGH
DOWNS
MENDIPS
Swindon
Reading
Basingstoke
Andover
Salisbury
Winchester
SOUTHAMPTON
Portsmouth
Bournemouth
Weymouth
ISLE OF WIGHT
Yeovil
Weston super Mare
Bridgwater
ENGLISH AND WELSH GROUNDS LT FLOAT
KEMBLE
BRIZE NORTON
SOUTH MARSTON
ABINGDON
EGD 012
EGD 013
EGD 014
EGD 021
EGD 026
A
B
C
D
E
F
G


Figure 3

RAF FAIRFORD METEOROLOGICAL

EQUIPMENT LOCATION

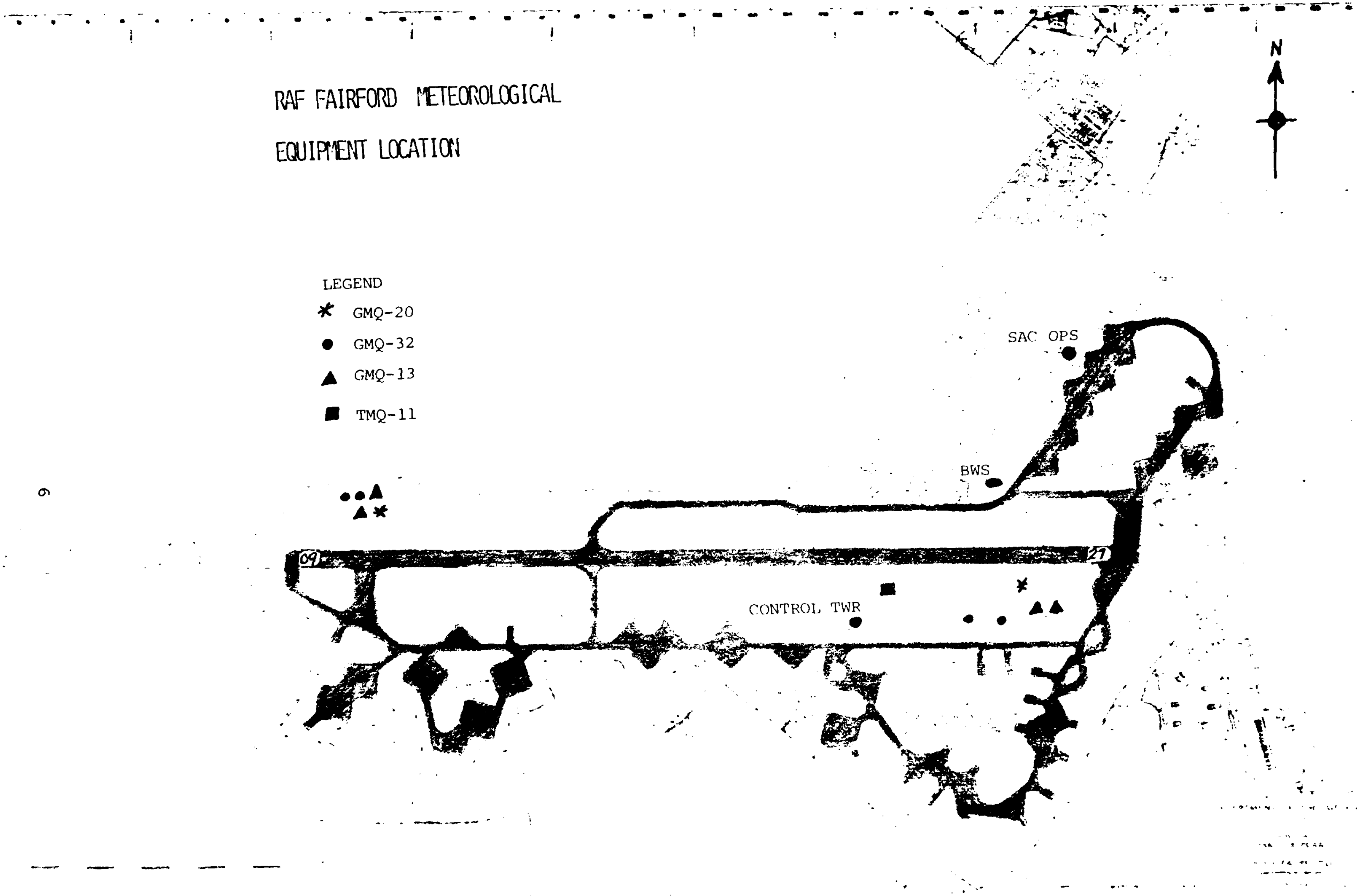



Figure 4

# SECTION II

# CLIMATIC AIDS

## CRITICAL WEATHER ELEMENTS

| PARAMENTER | 11SG/7020ABG ACTIONS | DET 18 ACTIONS |
|---|---|---|
| CIG < 600ft | Below circling minimums | SPL OBS |
| CIG < 500ft | Below TACAN minimums | SPL OBS |
| CIG < 200ft | A/C Operations restricted, below PAR minimums (Rnwy 09) | SPL OBS<br>MWA |
| CIG < 100ft | Below PAR landing minimums (Rnwy 27) | SPL OBS |
| VIS < 1.7NM | Below circling minimums | SPL OBS |
| VIS < 1.1NM | Possible take-off/recovery restrictions, below TACAN threshold | SPL OBS<br>MWA |
| VIS < 0.4NM | A/C operations restricted, below PAR Landing minimums, external lights used for A/C towing | SPL OBS<br>MWA |
| VIS < 0.2NM | A/C operations restricted, higher headquarters approval required for take-off | SPL OBS<br>MWA |
| VIS < 0.1NM | A/C operations restricted, below minimum take-off minimums, no towing, sentry density increased | SPL OBS<br>MWA |
| RVR 2400ft | Take-off alternates required | Brief |
| Snow forecasted in next 12 hours | Snow control personnel placed in standby recall | MWA |
| 1" snow in 6 hours | A/C movement restricted, A/C de-icing vehicles readied, tire chains mounted, runway clearing started, speed limits reduced on-base | WX WRNG |
| Freezing Precip | A/C movement restricted, no take-offs, A/C de-icing vehicles readied, tire chains mounted, on-base speed limits reduces, runway clearing started | WX WRNG |
| Hail ≥ 1/2" | Outdoor maintenance activities curtailed | WX WRNG |
| 6kt crosswind on wet runway or RCR is < 09 | A/C operations restricted | MWA |
| 25 kt. crosswind | A/C operations restricted, no take-offs or landings | MWA |
| Surface winds 25-34 kts. | A/C maintenance activities restricted | MWA |
| Surface winds 35-49 kts. | Equipment secured, outdoor maintenance activities curtailed | WX WRNG |

| PARAMENTER | 11SG/7020ABG ACTIONS | DET 18 ACTIONS |
|---|---|---|
| Surface winds 50-64 kts | Equipment removed from flight line, small aircraft hangared, outdoor maintenance activities stopped, ATC tower evacuated | WX WRNG |
| Surface winds > 64 kts | A/C faced into the wind | WX WRNG |
| Tornadoes | All personnel notified to take protective actions | WX WRNG |
| Temperature below 40°F | Engine water heated/dumped, water trucks hangared | MWA |
| Temperature below 20°F | Engine water dumped, no wet take-offs, outdoor patrol activity shortened | MWA |
| Freezing Fog | Tire chains mounted, on-base speed limits reduces | MWA |
| Lightning within 5NM | Terminate fuel/maintenance activities power down computers | MWA |
| Lightning within 1 NM | Terminate outdoor maintenance activities, evacuate filghtline, computer operations terminated | MWA |
| Probability of lightning conditions (POLC) 80% within 25 NM | A/C operations restricted, touch-and-go's curtailed | MWA |
| Low level wind shear | A/C operations restricted, touch-and-go's curtailed | MWA |
| MDT or greater TURBC below 10,000 ft within 10 NM of EGVA | A/C operations restricted, hazards avoided | MWA |
| MDT or greater TURBC above 10,000 ft within 50 NM of EGVA | A/C operations restricted, hazards avoided | MWA |

PRESSURE VARIATIONS

A diurnal pressure curve for RAF Fairford under a stagnant pressure system shows little variation. The highest diurnal change is only .026 inches during March, while October has the least diurnal change with only .016 inches.

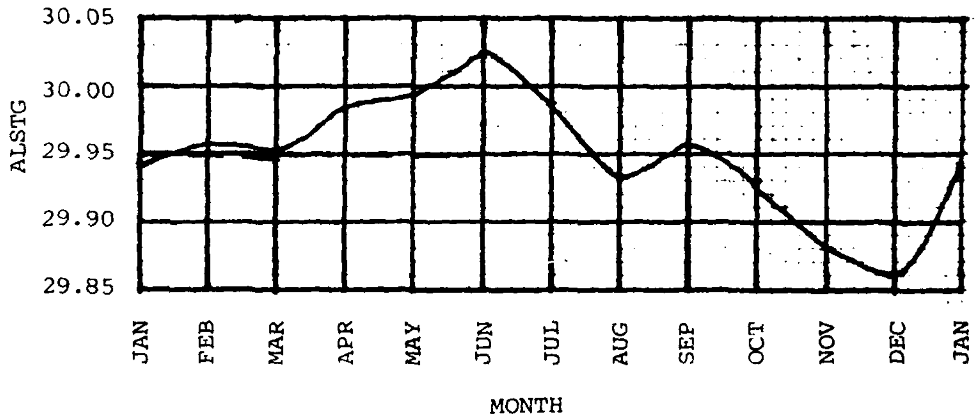
The diurnal variations that there are occur at the following times:

Pressure falls -- 00-06Z/12-17Z

Pressure rises -- 06-12Z/17-24Z

The times shift slightly from winter to summer. During the summer, the diurnal variation occurs one hour latter than shown above.

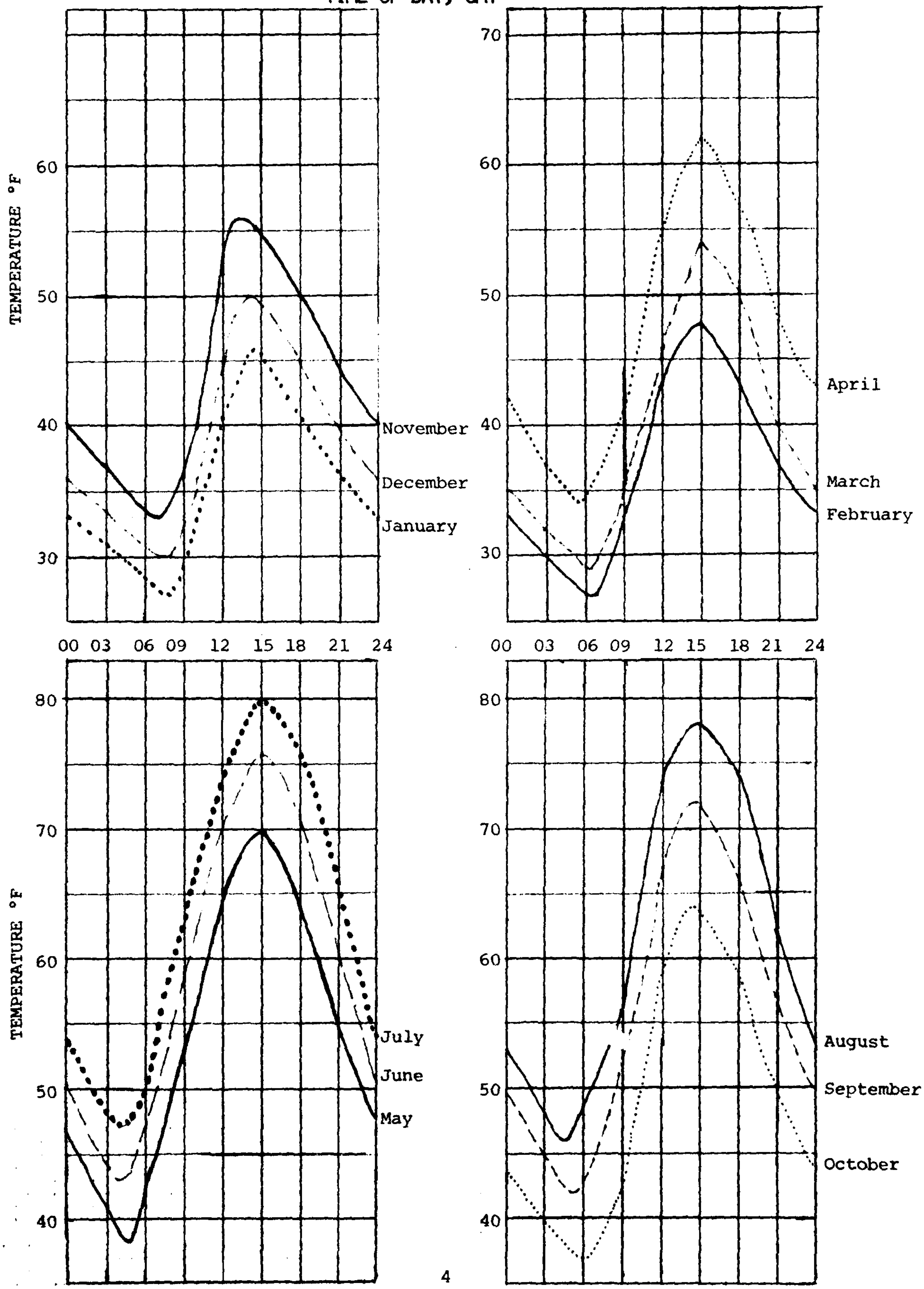
The graph below shows the annual pressure variations for Fairford, along with the mean ALSTGs for the months.

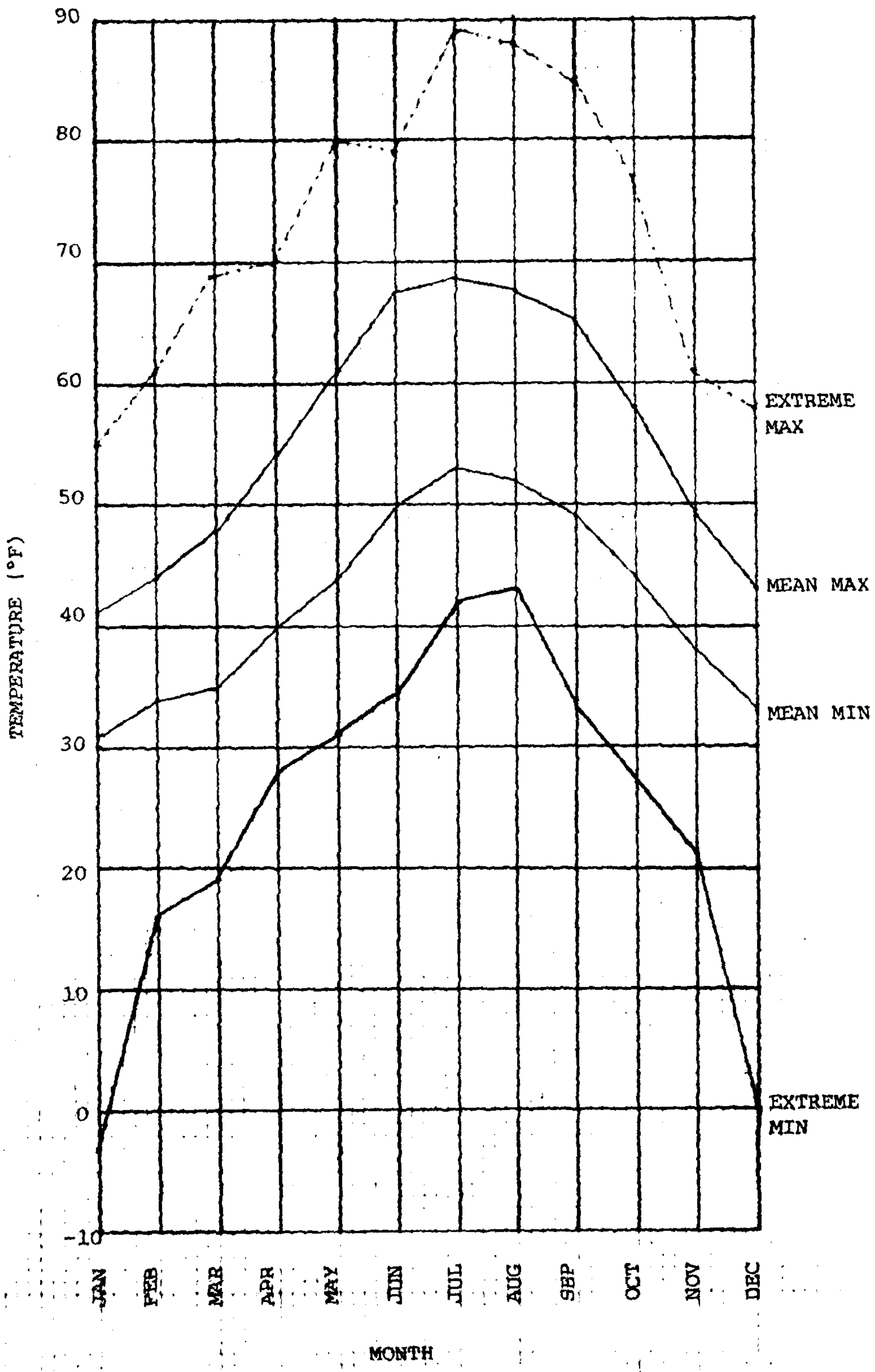



ANNUAL PRESSURE CURVE

# RAF FAIRFORD

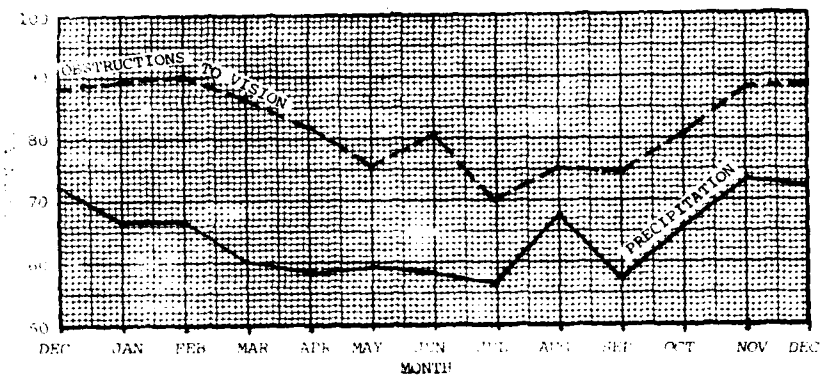
MEAN TEMPERATURES FOR RADIATION CONDITIONS
TIME OF DAY, GMT

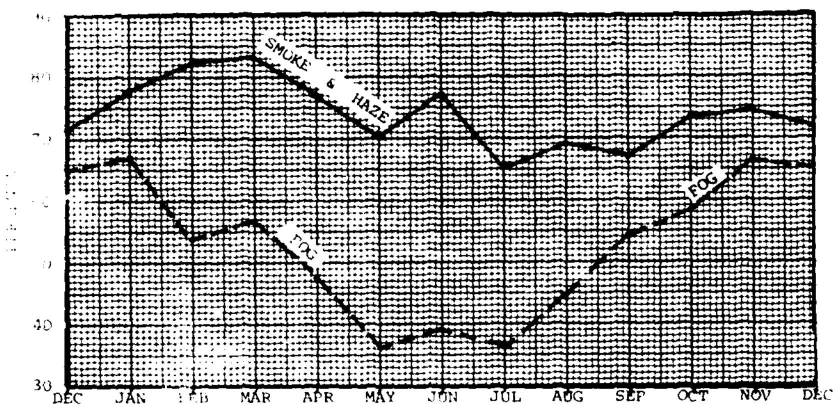


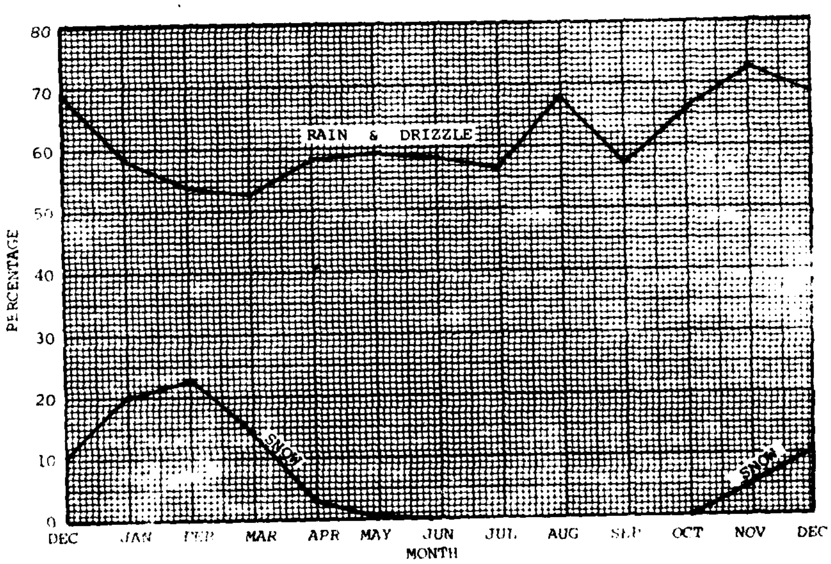



ANNUAL TEMPERATURE CURVE

PERCENTAGE OF DAYS PER MONTH WITH
WEATHER AND OBSTRUCTIONS TO VISION



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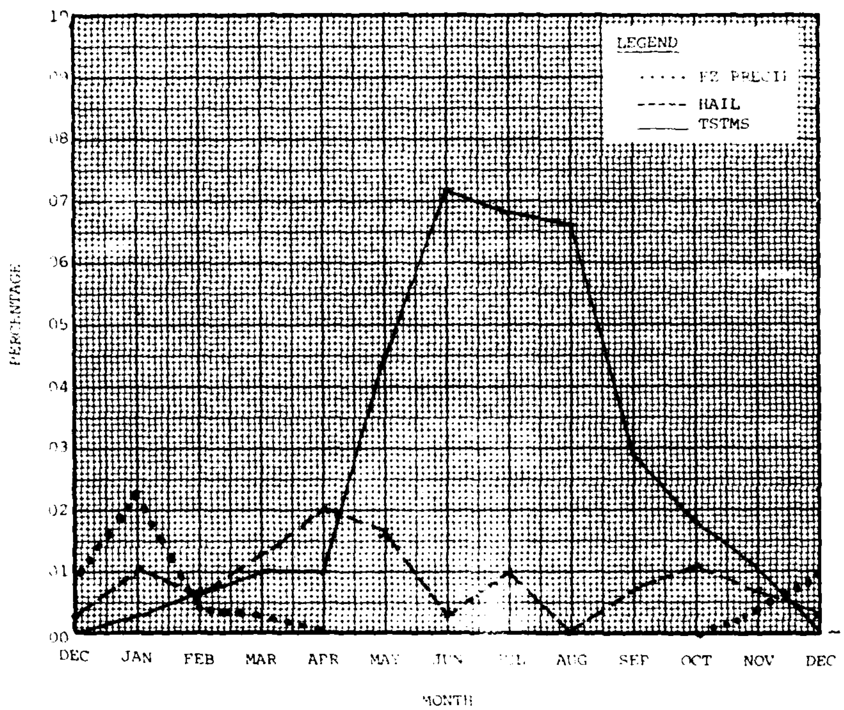
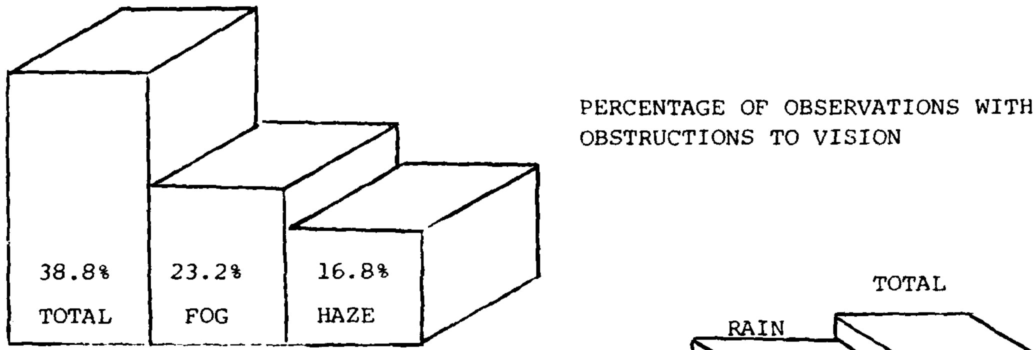
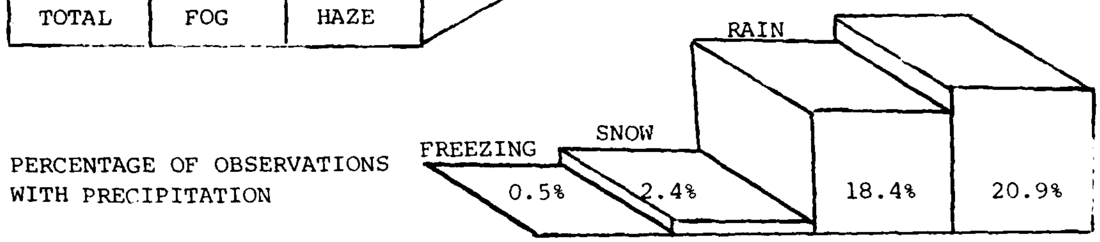


JANUARY

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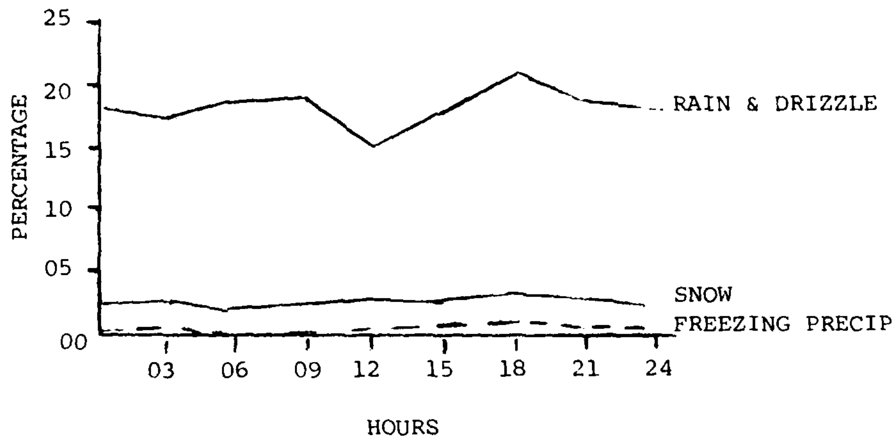


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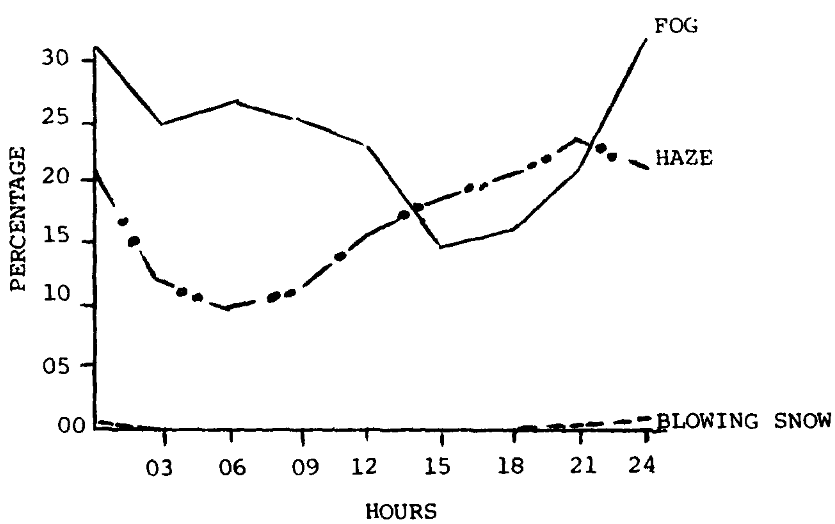

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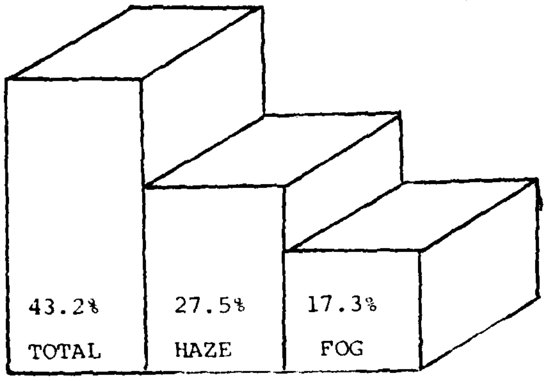


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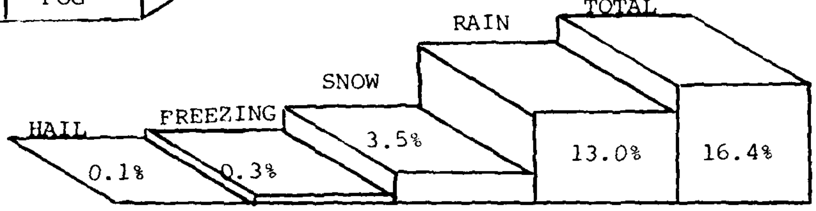


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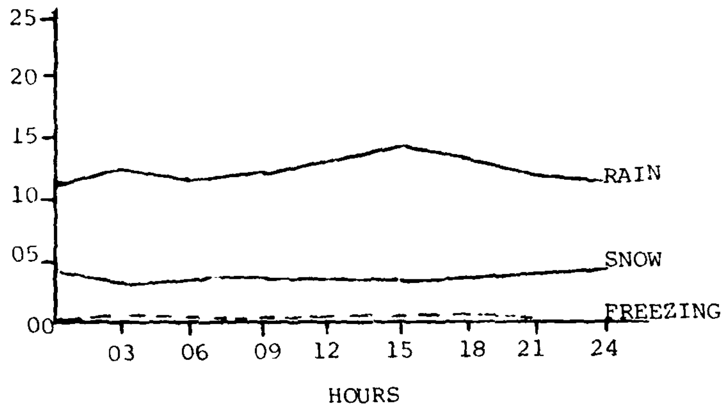


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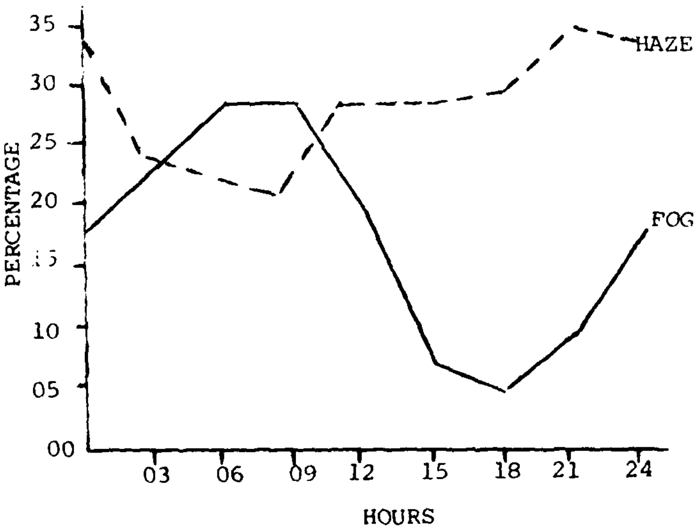

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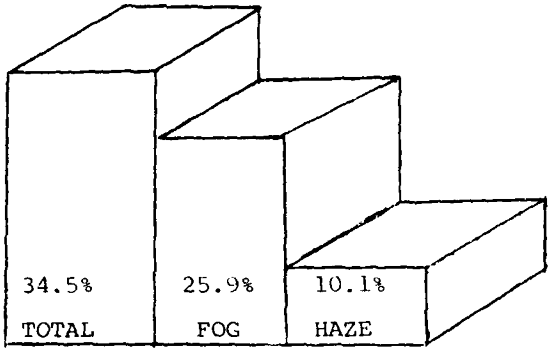


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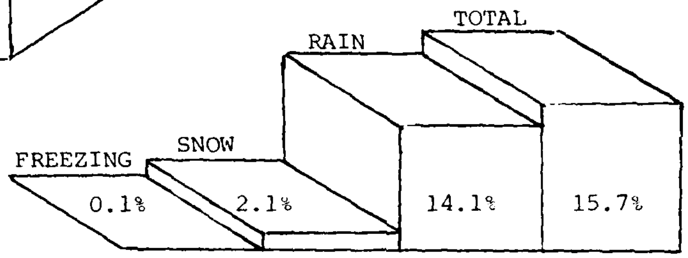


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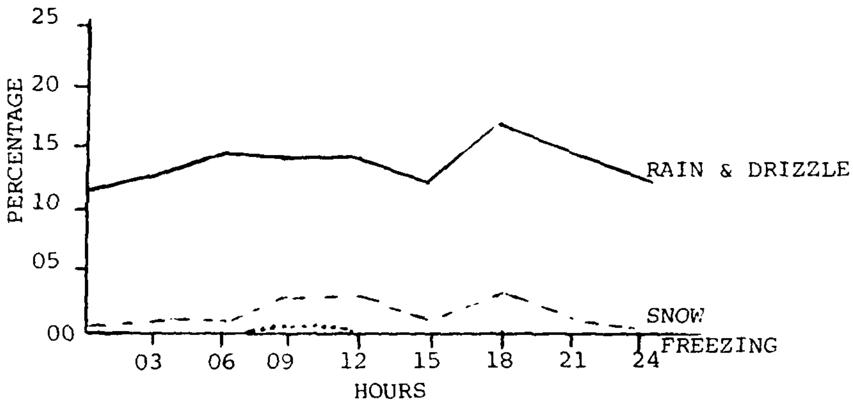


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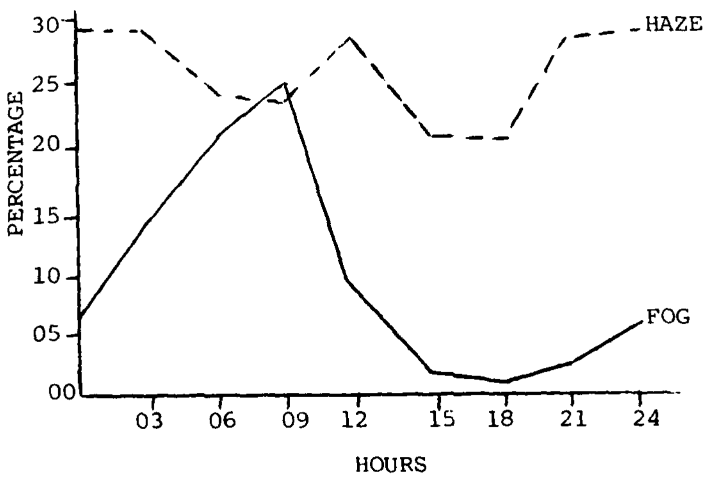

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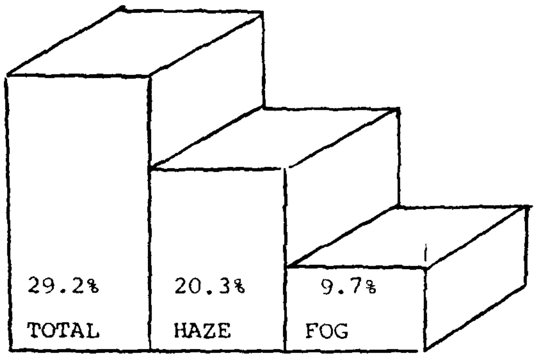


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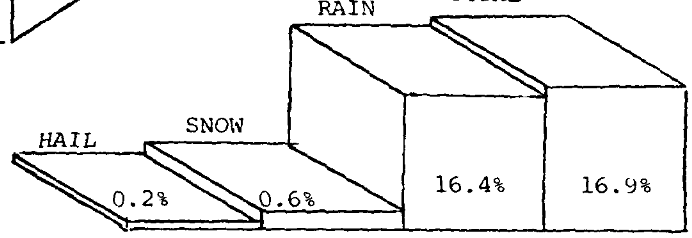


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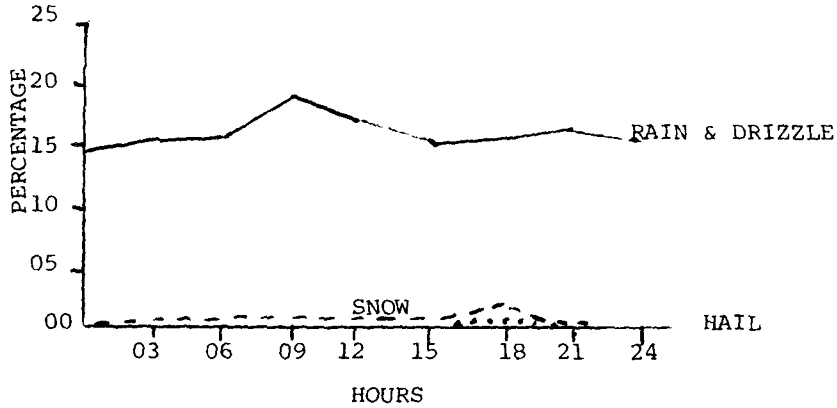


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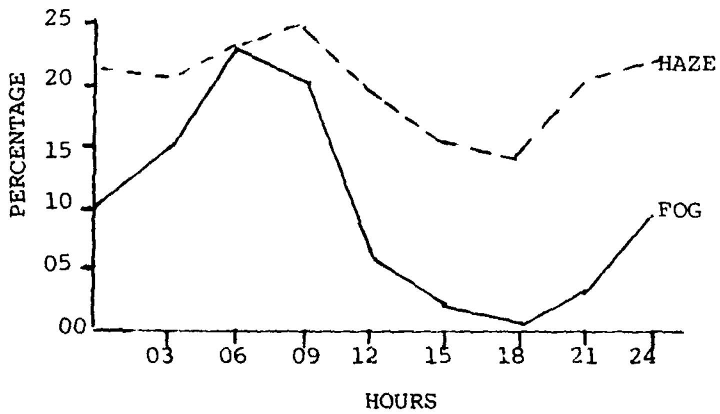

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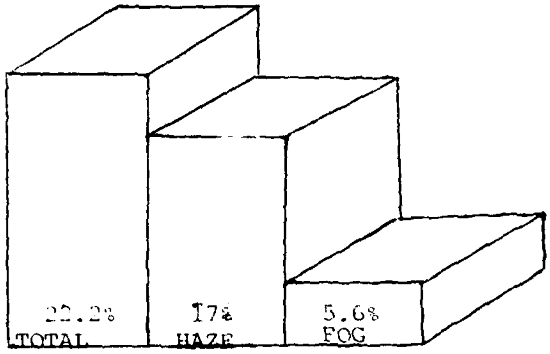


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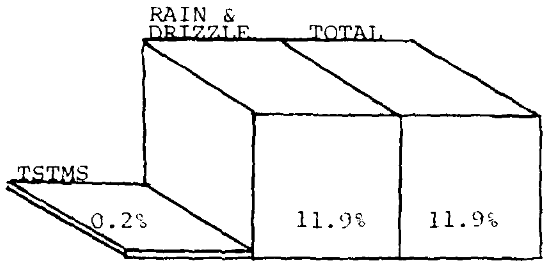


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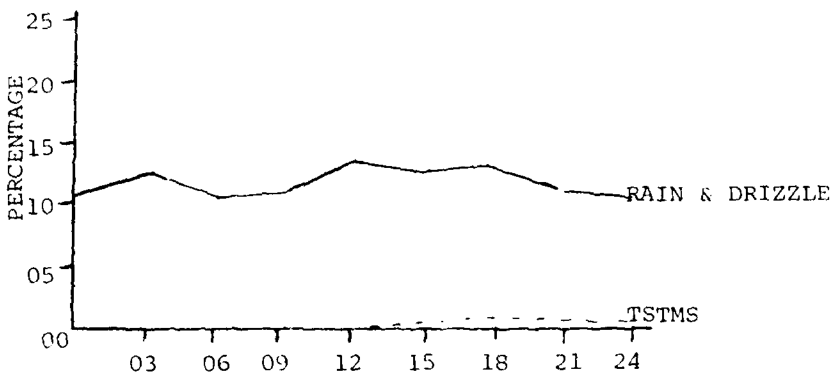


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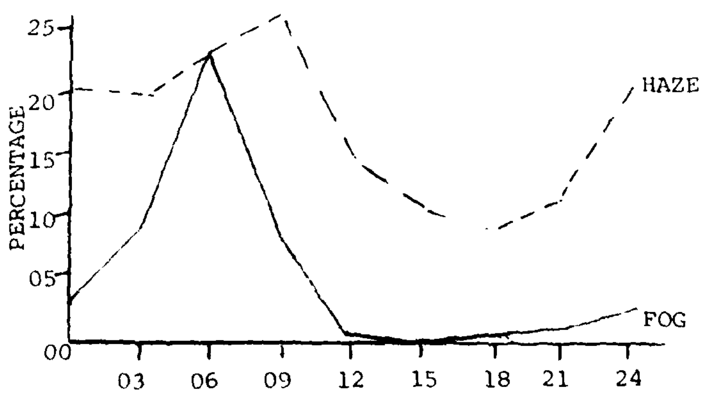

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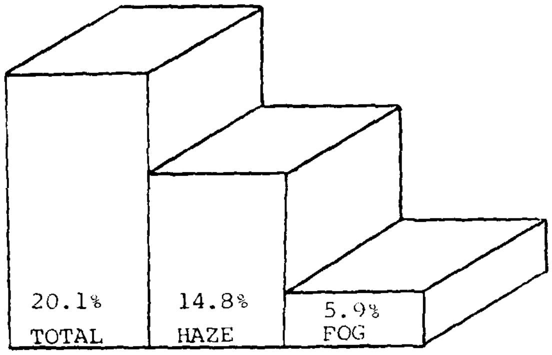


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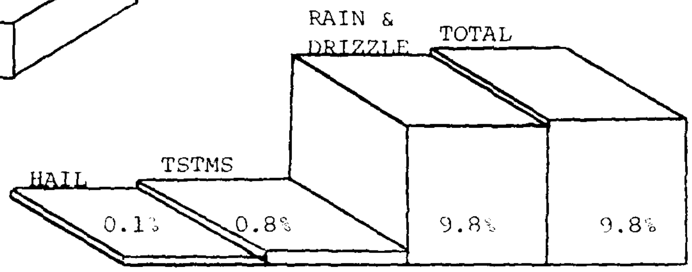


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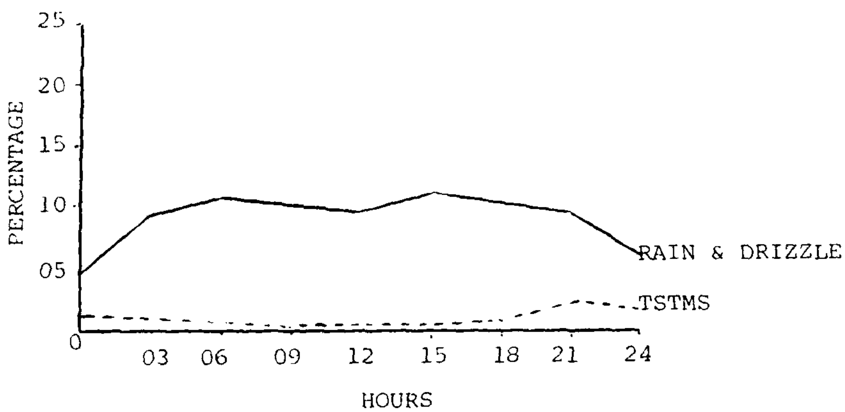


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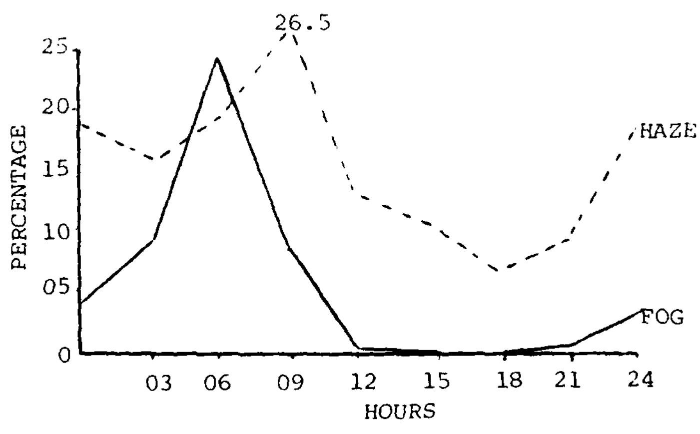

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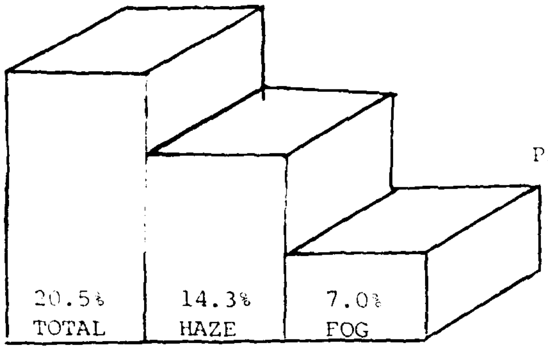
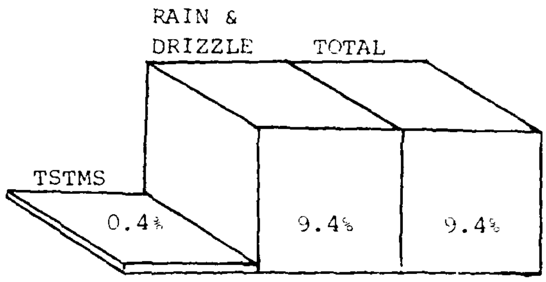


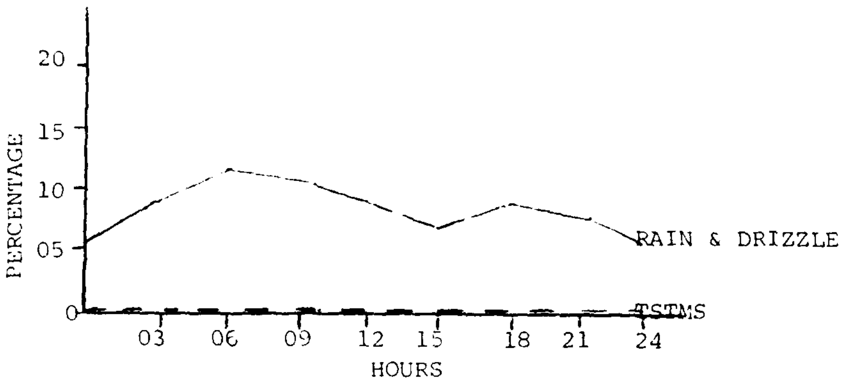

PERCENTAGE OF OBSERVATIONS WITH OBSTRUCTIONS TO VISION



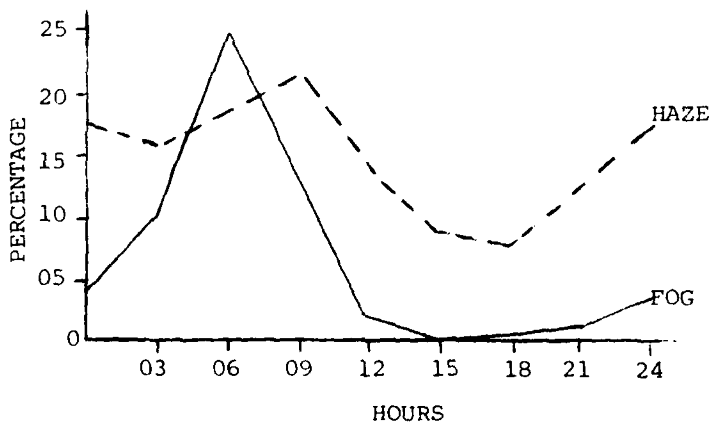

PERCENTAGE OF OBSERVATIONS WITH PRECIPITATION

PERCENTAGE OF OBSERVATIONS BY HOURS WITH:

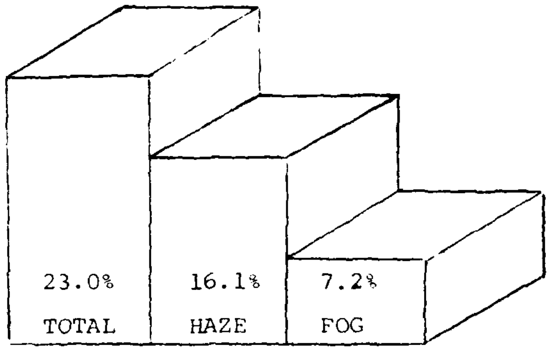
PRECIPITATION



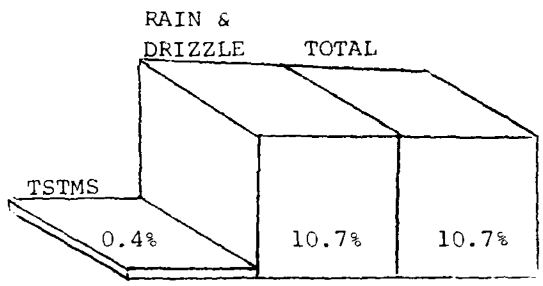

OBSTRUCTIONS TO VISION



AUGUST



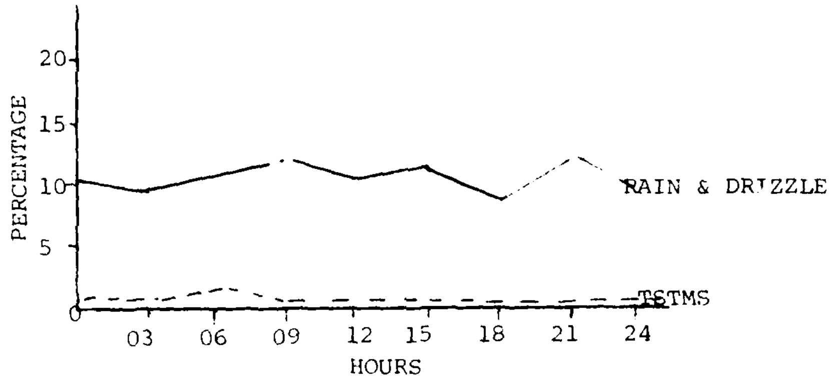

PERCENTAGE OF OBSTERVATIONS WITH OBSTRUCTIONS TO VISION



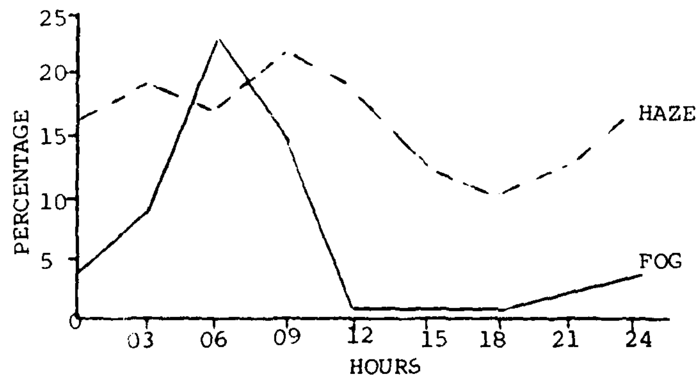

PERCENTAGE OF OBSERVATIONS WITH PRECIPITATION

PERCENTAGE OF OBSERVATIONS BY HOURS WITH:

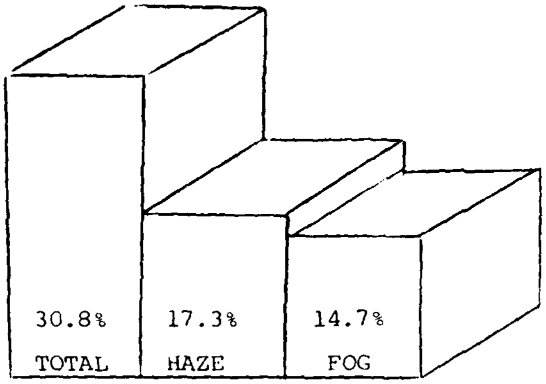
PRECIPITATION




OBSTRUCTIONS TO VISION

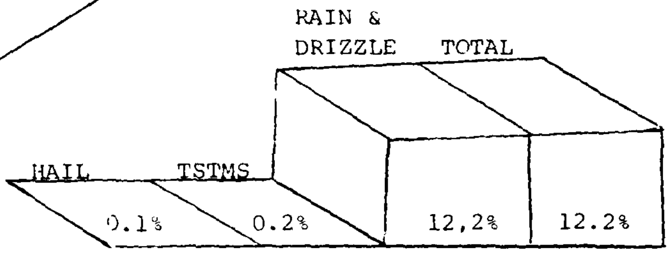


SEPTEMBER



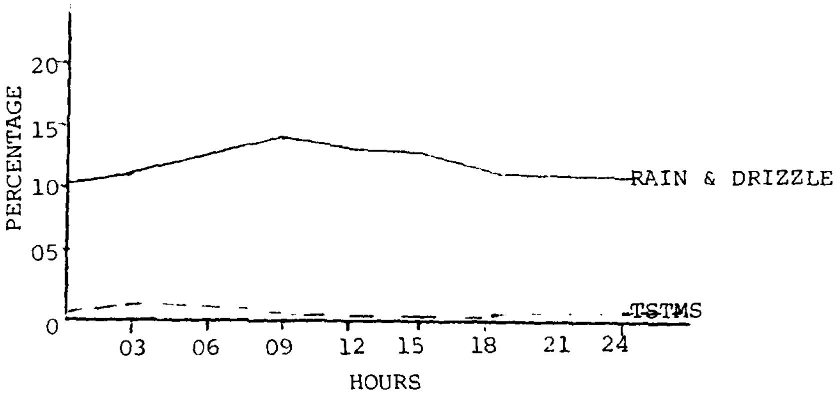

PERCENTAGE OF OBSERVATIONS WITH OBSTRUCTIONS TO VISION

PERCENTAGE OF OBSERVATIONS WITH PRECIPITATION

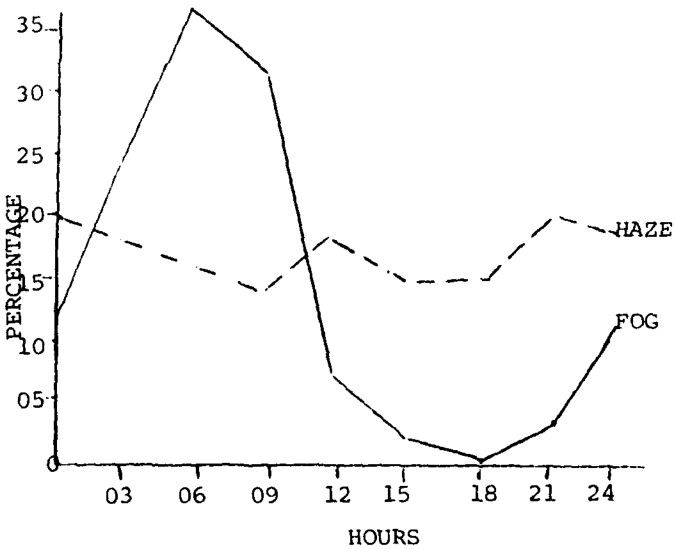



PERCENTAGE OF OBSERVATIONS BY HOURS WITH:

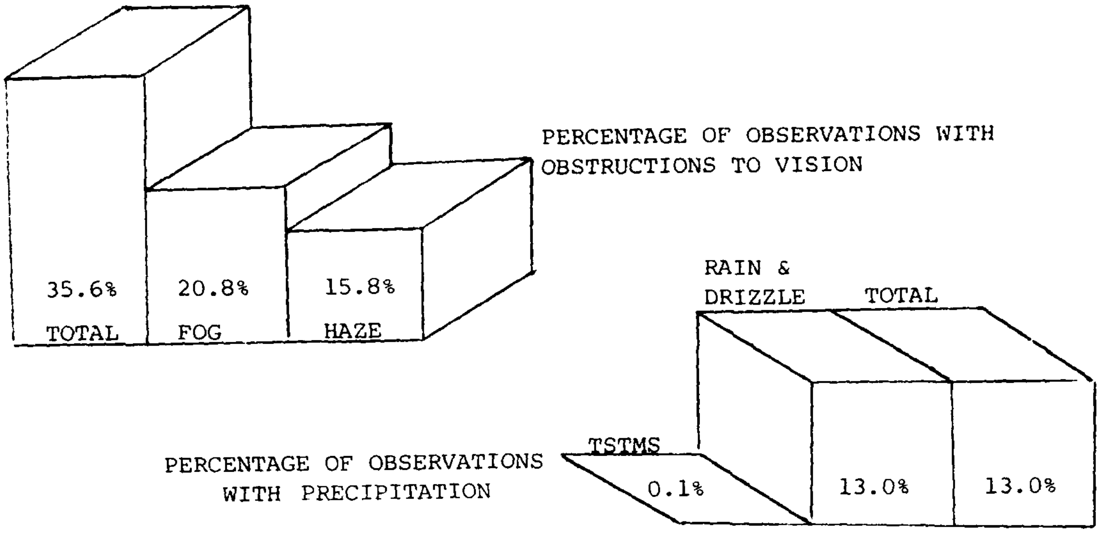
PRECIPITATION

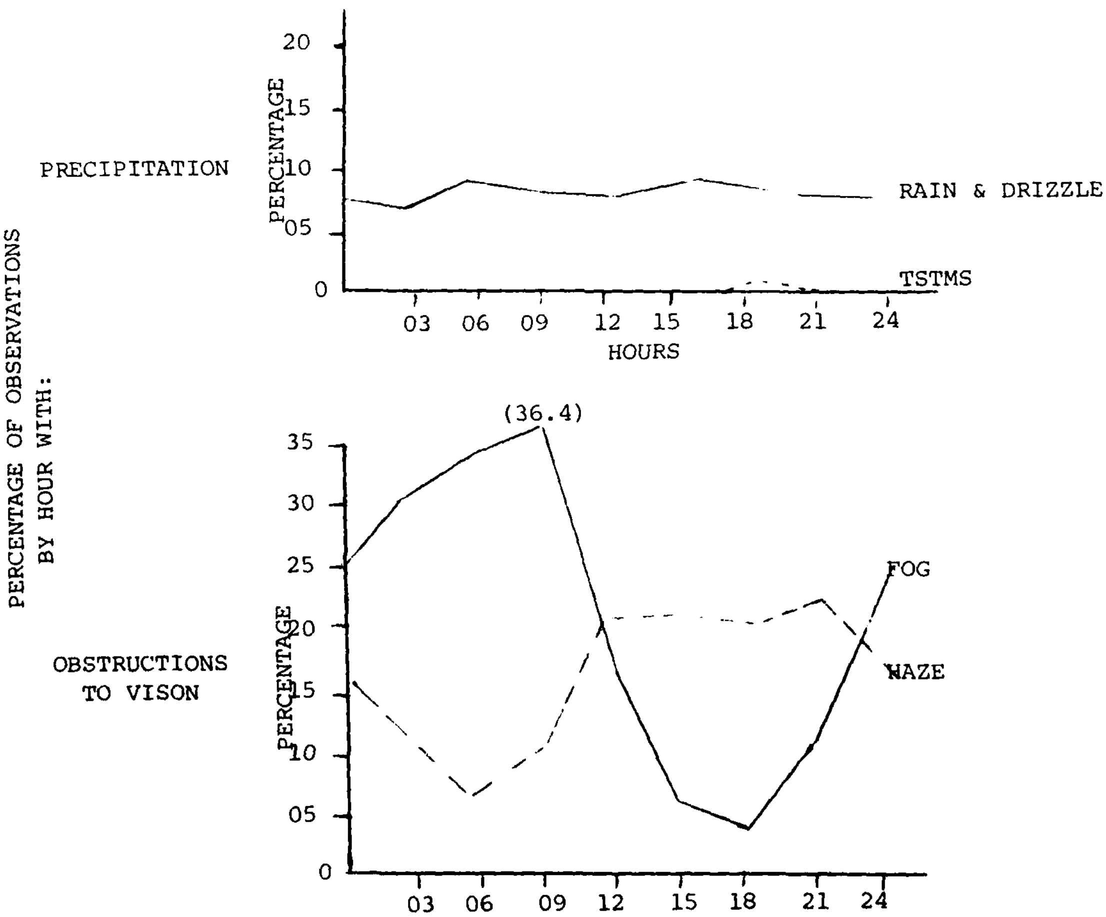



OBSTRUCTIONS TO VISION

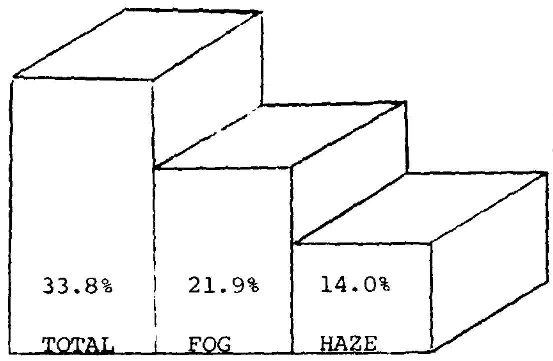


OCTOBER

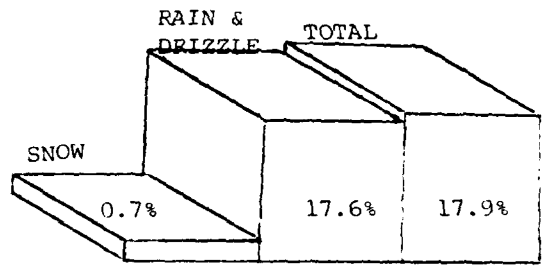

PERCENTAGE OF OBSERVATIONS WITH OBSTRUCTIONS TO VISION
35.6%
TOTAL
20.8%
FOG
15.8%
HAZE
PERCENTAGE OF OBSERVATIONS WITH PRECIPITATION
TSTMS
0.1%
RAIN & DRIZZLE
13.0%
TOTAL
13.0%


PERCENTAGE OF OBSERVATIONS BY HOUR WITH:
PRECIPITATION
PERCENTAGE
20
15
10
05
0
RAIN & DRIZZLE
TSTMS
03 06 09 12 15 18 21 24
HOURS
OBSTRUCTIONS TO VISON
PERCENTAGE
(36.4)
35
30
25
20
15
10
05
0
FOG
HAZE
03 06 09 12 15 18 21 24

NOVEMBER



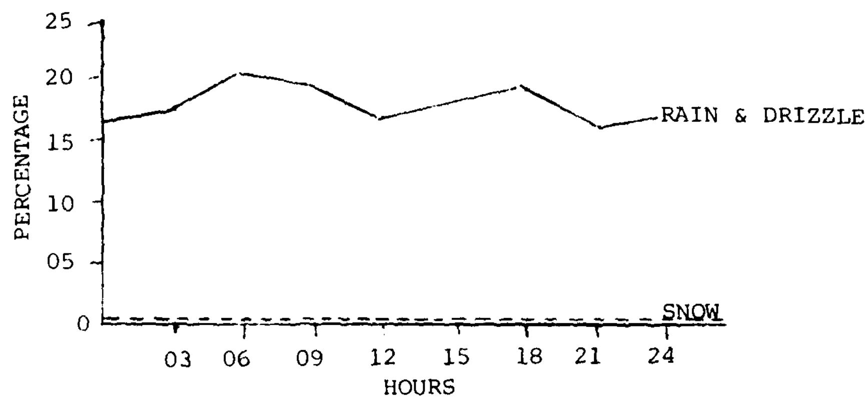

PERCENTAGE OF OBSERVATIONS WITH OBSTRUCTIONS TO VISION



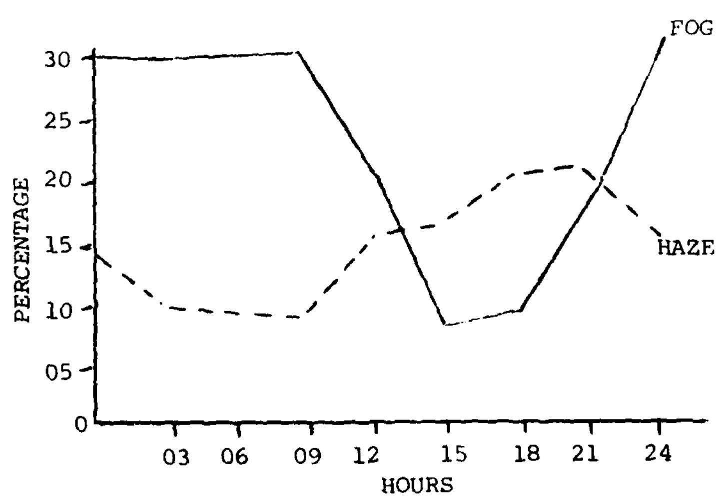

PERCENTAGE OF OBSERVATIONS WITH PRECIPITATION

PERCENTAGE OF OBSERVATIONS BY HOURS WITH:

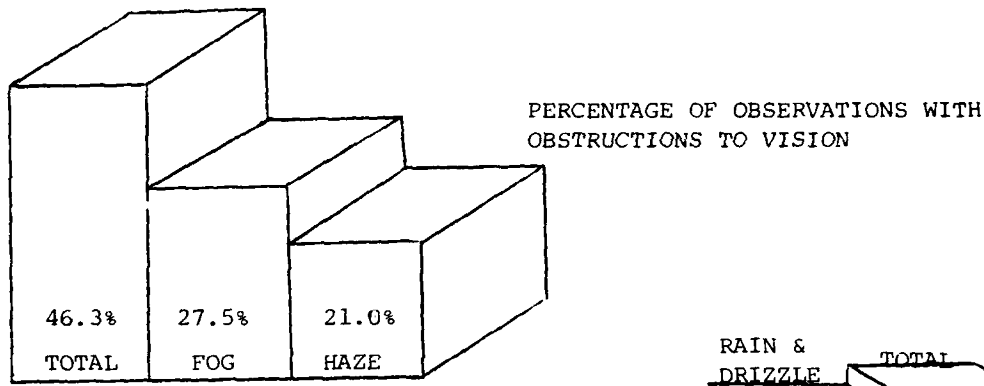
PRECIPITATION



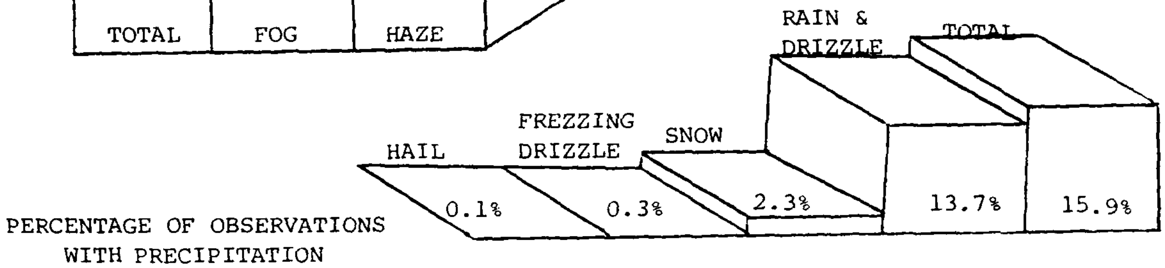

OBSTRUCTIONS TO VISION



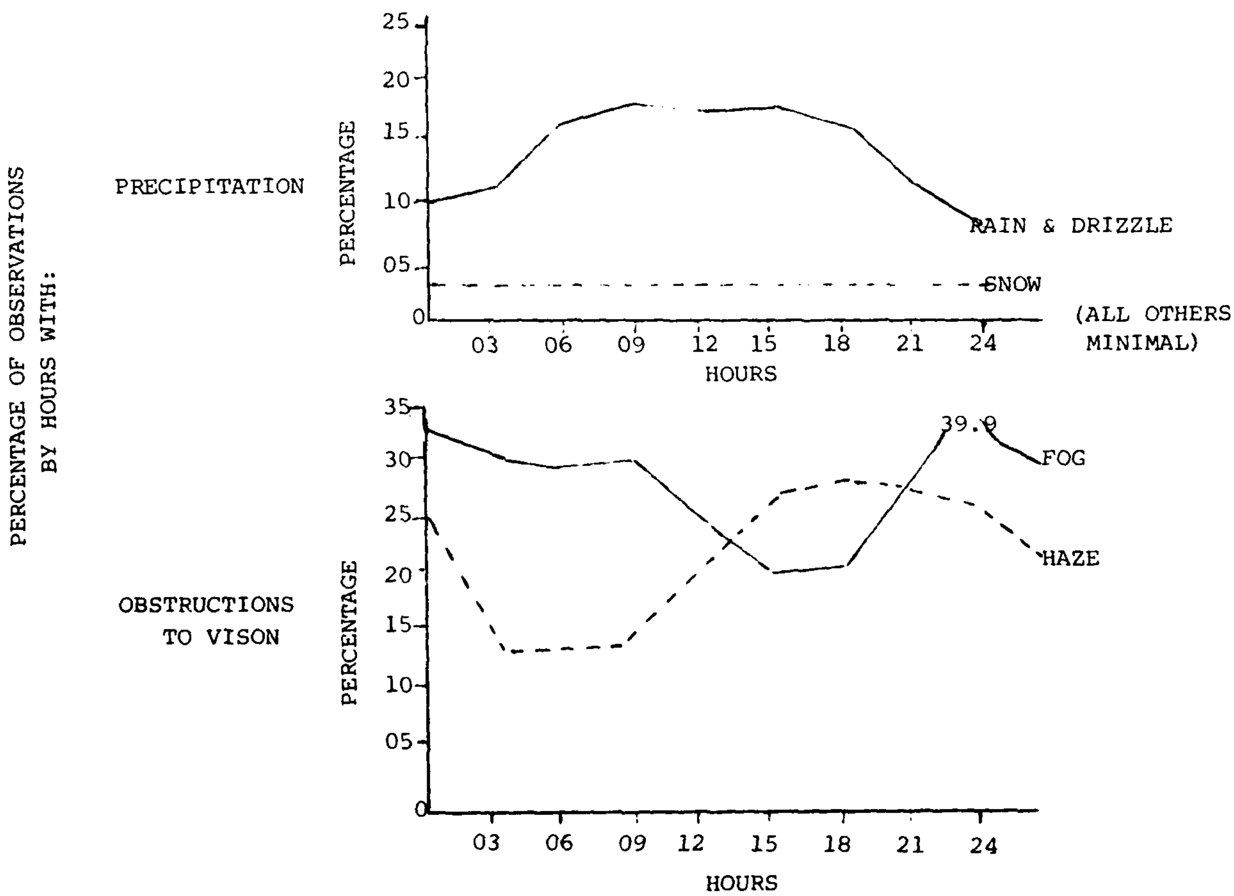
DECEMBER



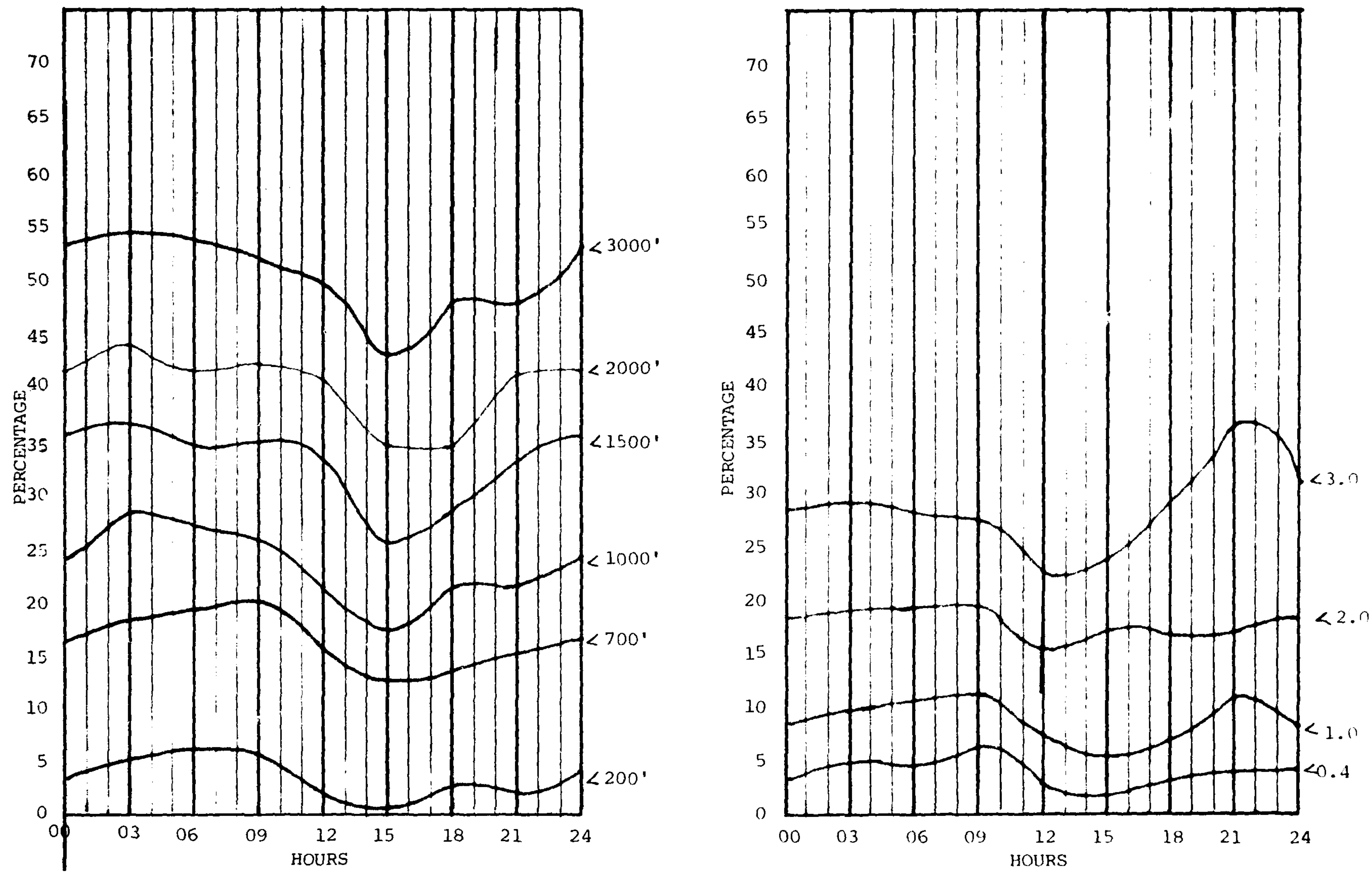
PERCENTAGE OF OBSERVATIONS WITH OBSTRUCTIONS TO VISION
46.3%
TOTAL
27.5%
FOG
21.0%
HAZE

HAIL
0.1%
FREZZING DRIZZLE
0.3%
SNOW
2.3%
RAIN & DRIZZLE
13.7%
TOTAL
15.9%
PERCENTAGE OF OBSERVATIONS WITH PRECIPITATION

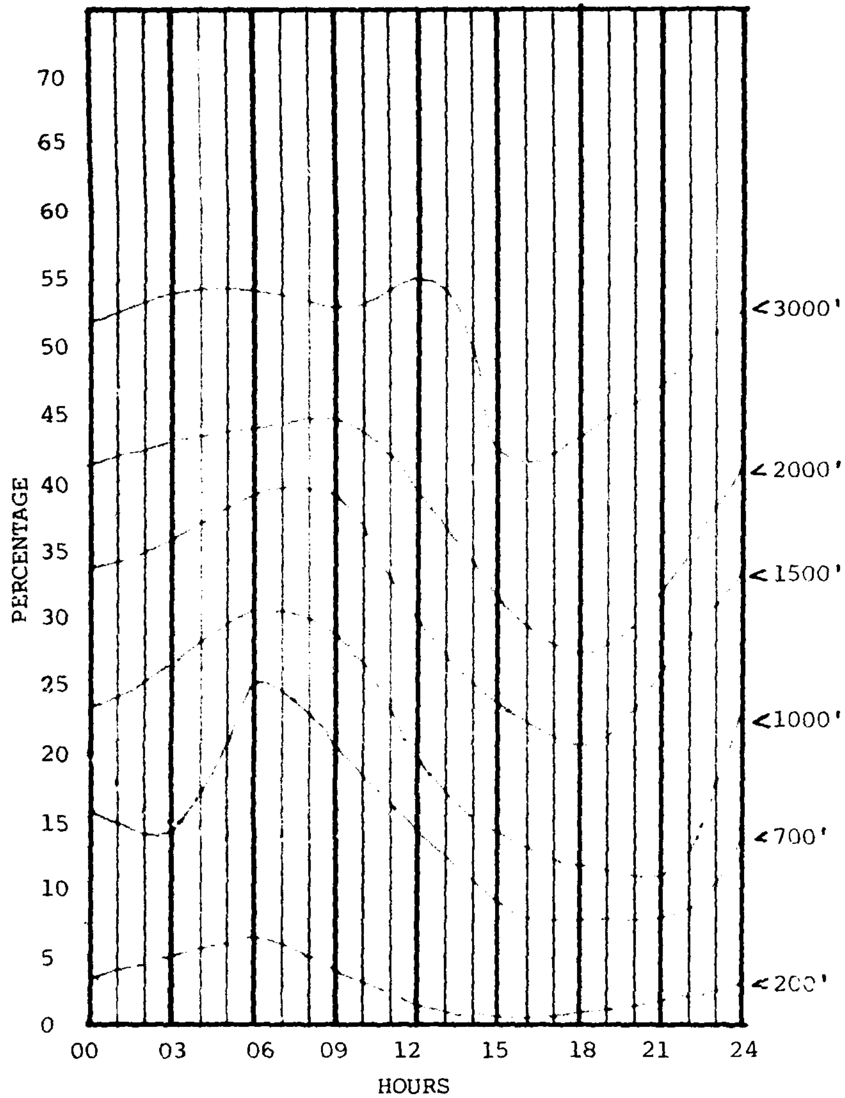



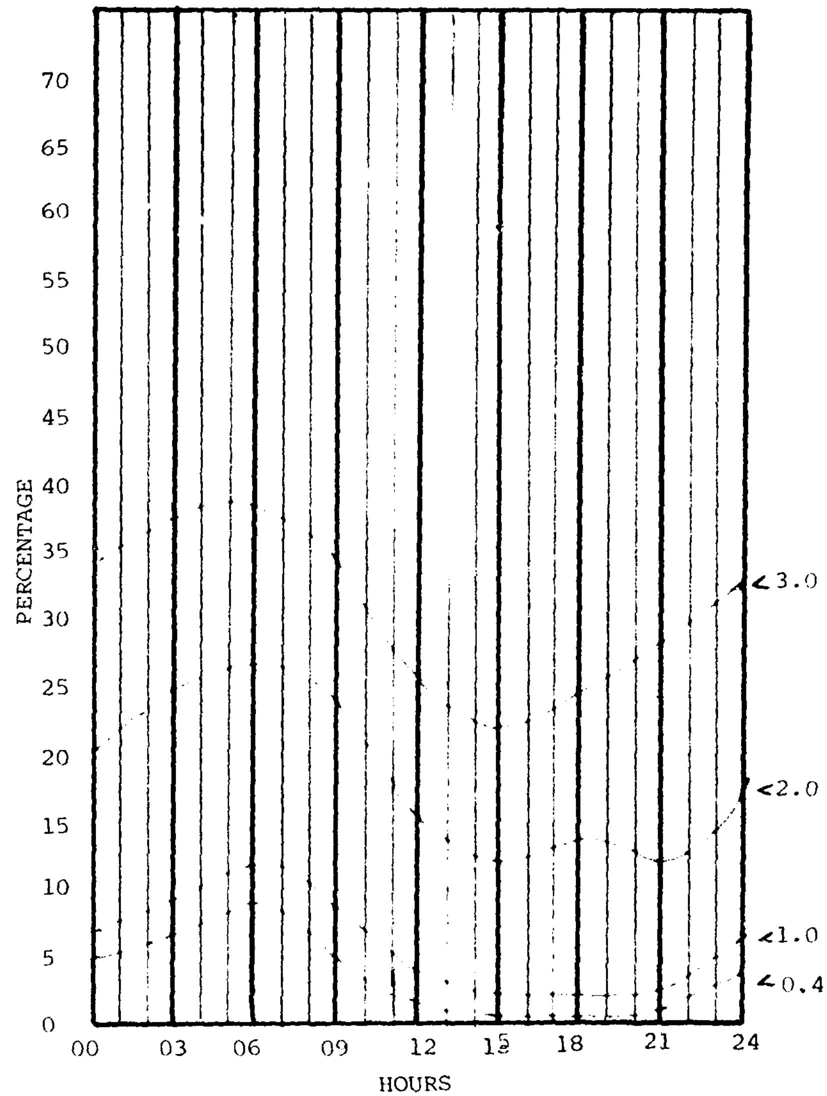
PERCENTAGE OF OBSERVATIONS BY HOURS WITH:
PRECIPITATION
PERCENTAGE
25
20
15
10
05
0
RAIN & DRIZZLE
SNOW
(ALL OTHERS MINIMAL)
03
06
09
12
15
18
21
24
HOURS
OBSTRUCTIONS TO VISON
PERCENTAGE
35
30
25
20
15
10
05
0
39.9
FOG
HAZE
03
06
09
12
15
18
21
24
HOURS




CEILING JANUARY VISIBILITY (Nautical Miles)

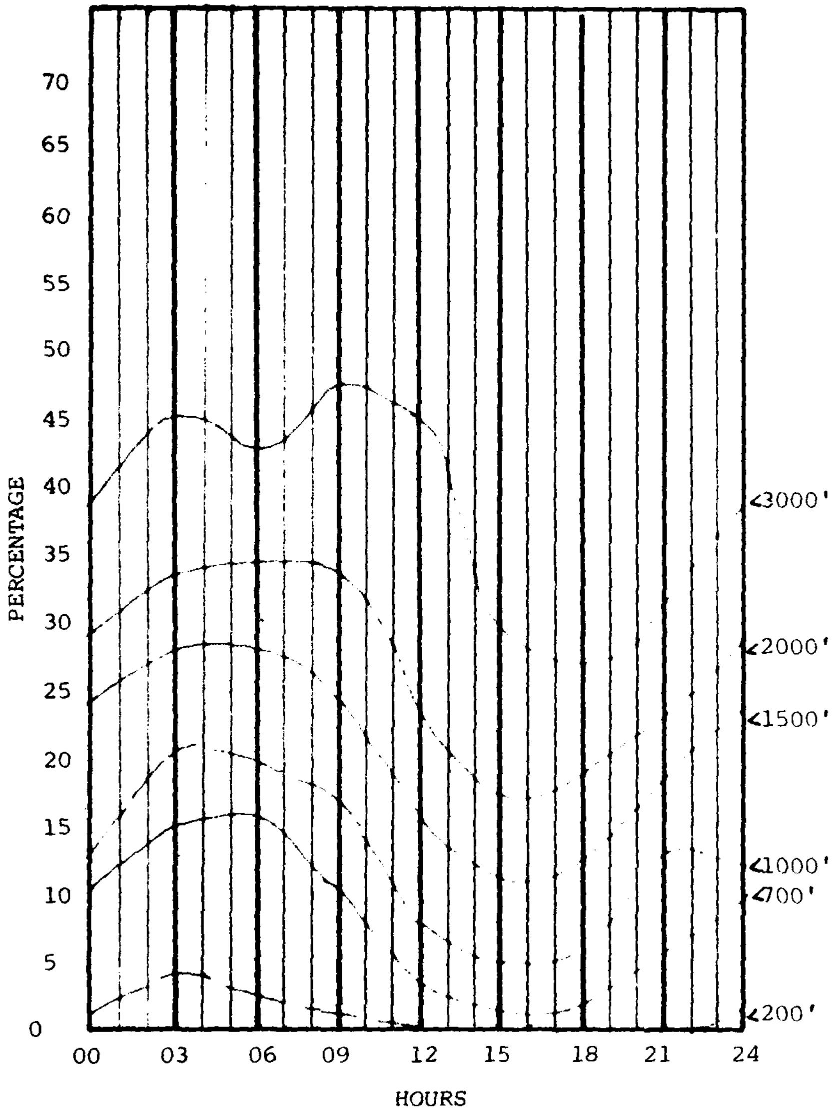
PERCENTAGE FREQUENCY OF OCCURRENCE

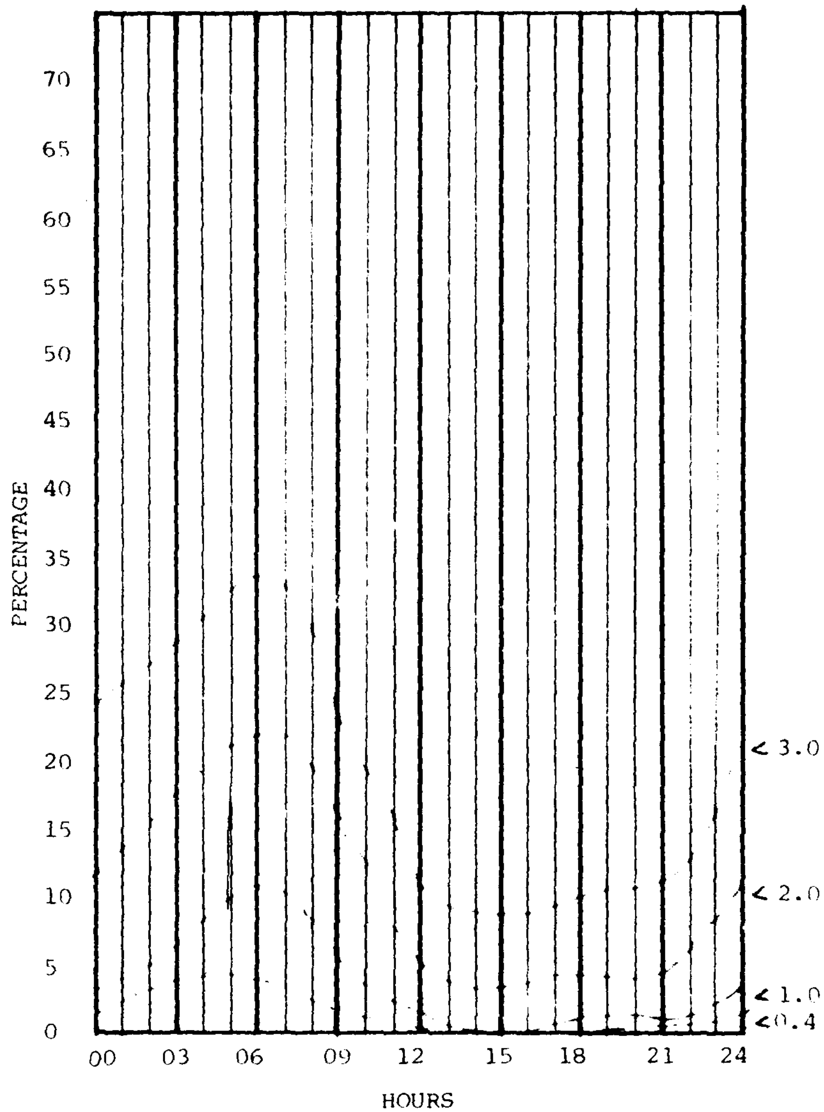



CEILING FEBRUARY VISIBILITY (Nautical Miles)

PERCENTAGE FREQUENCY OF OCCURRANCE



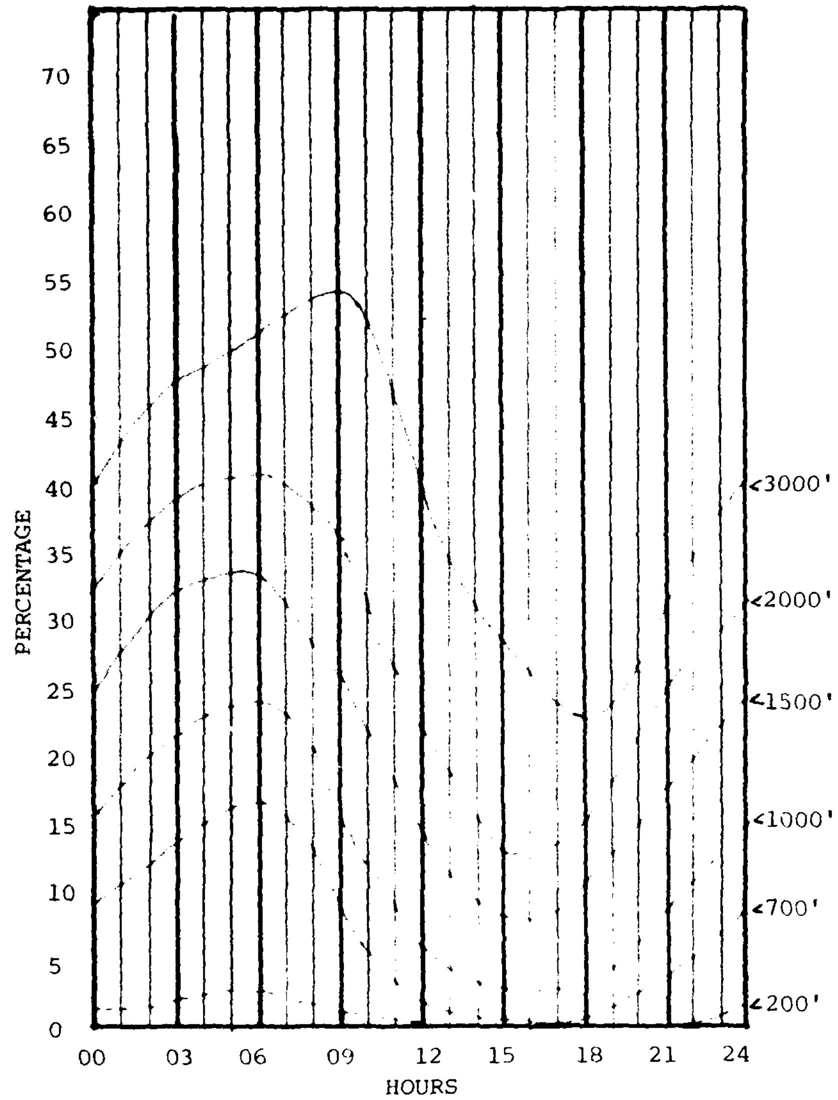



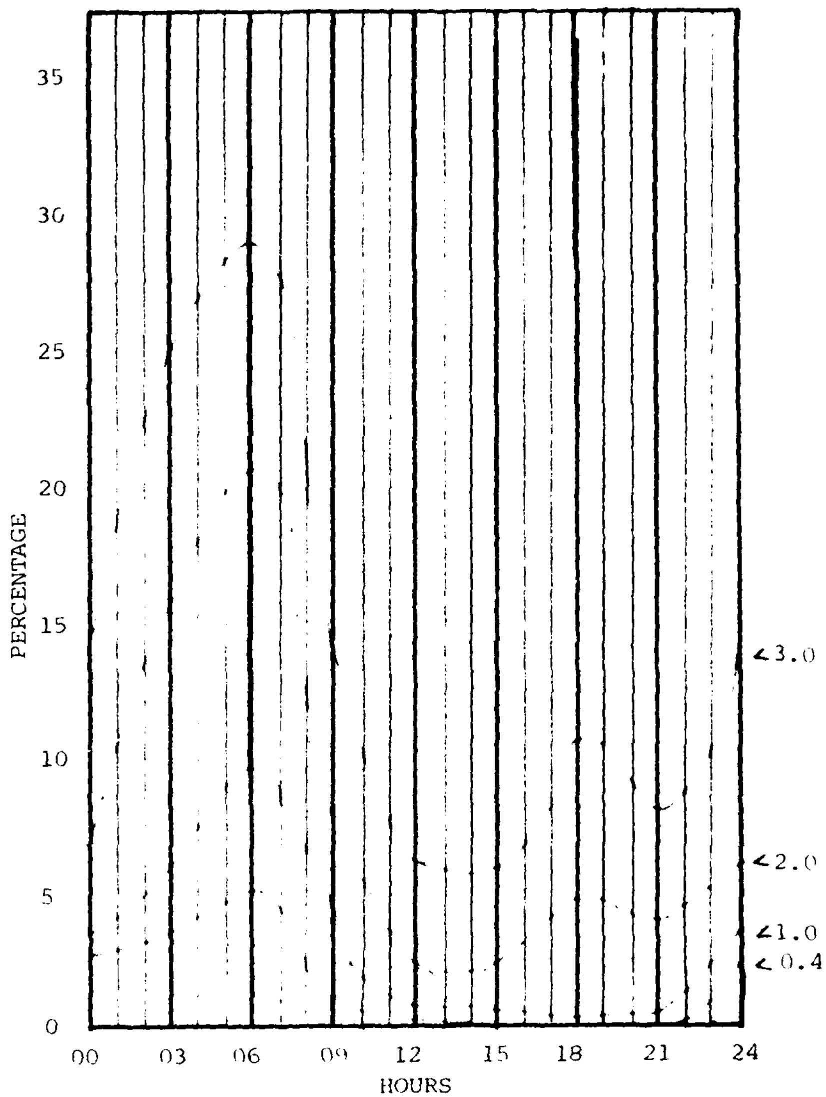

CEILING

MARCH

VISIBLITY ( Nautical Miles)

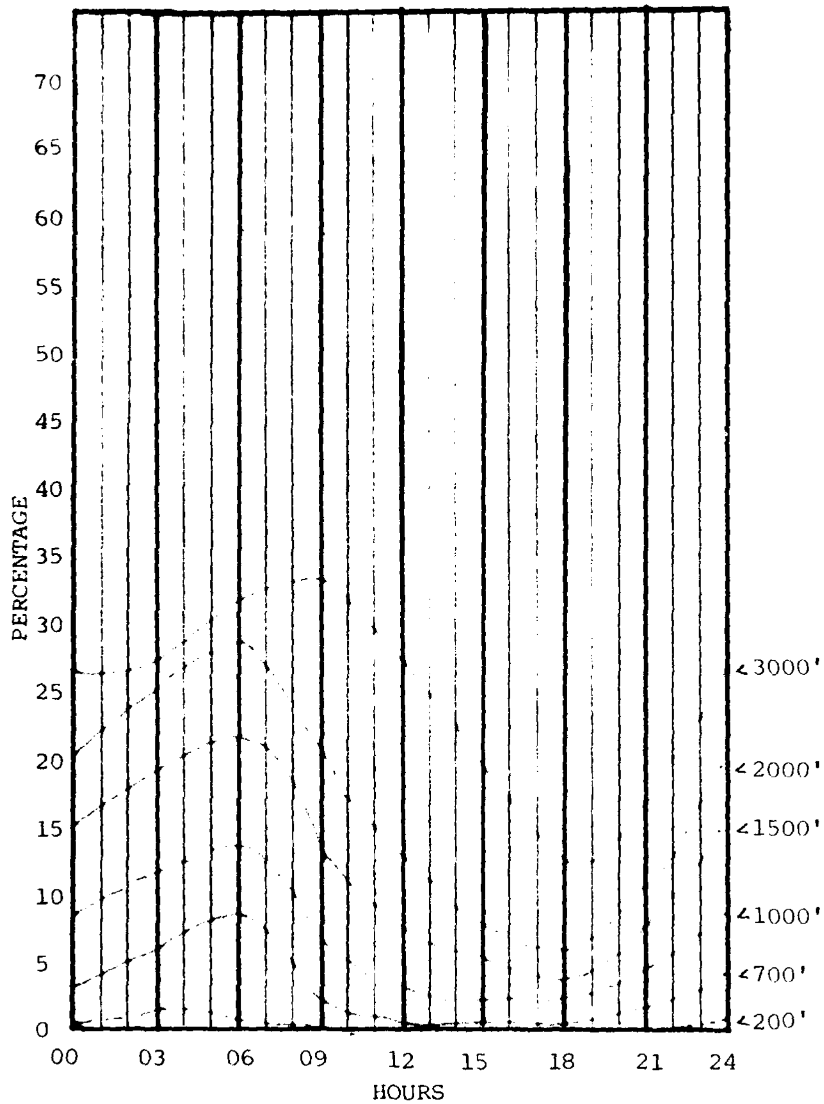
PERCENTAGE FREQUENCY OF OCCURRENCE

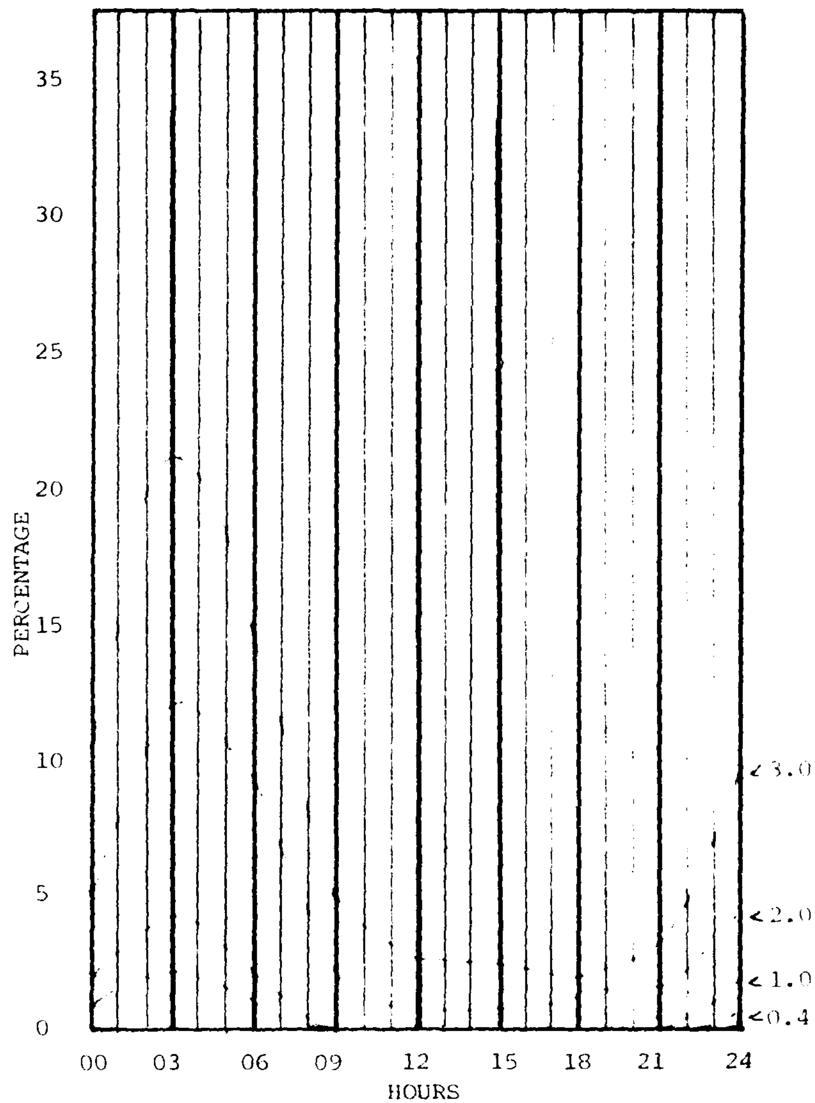



CEILING APRIL VISIBILITY (Nautical Miles)

PERCENTAGE FREQUENCY OF OCCURRENCE



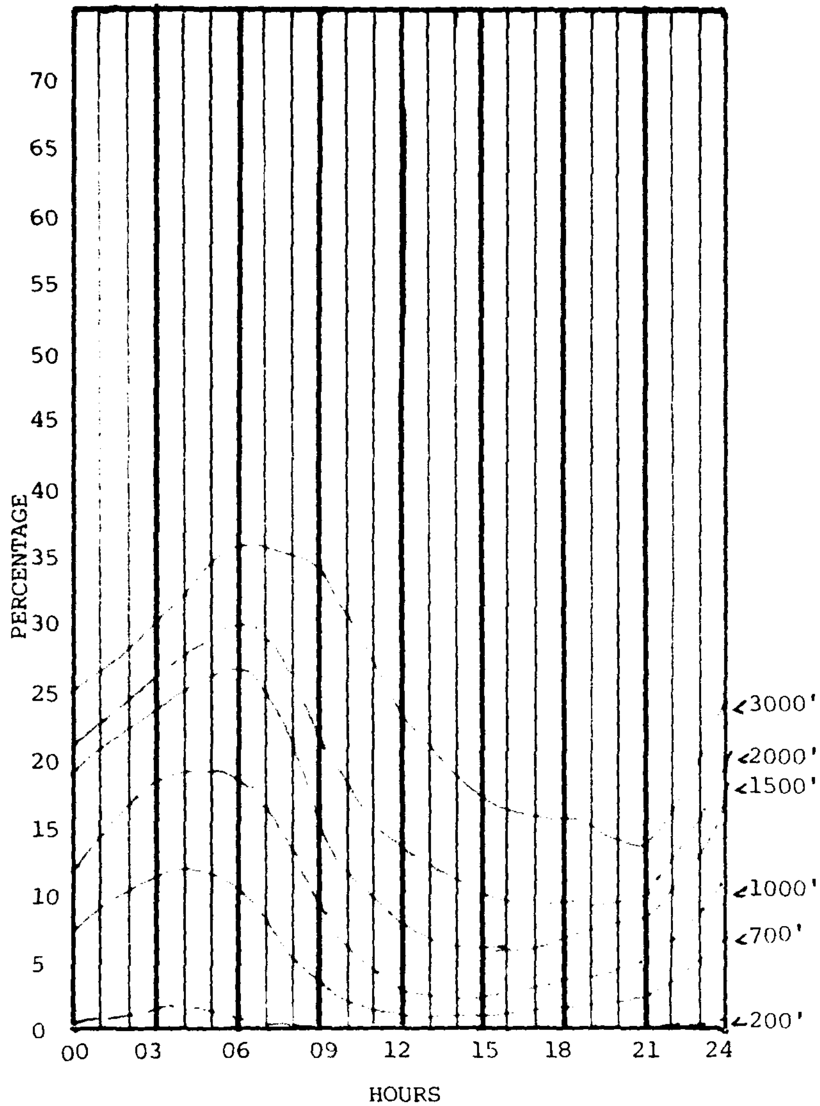



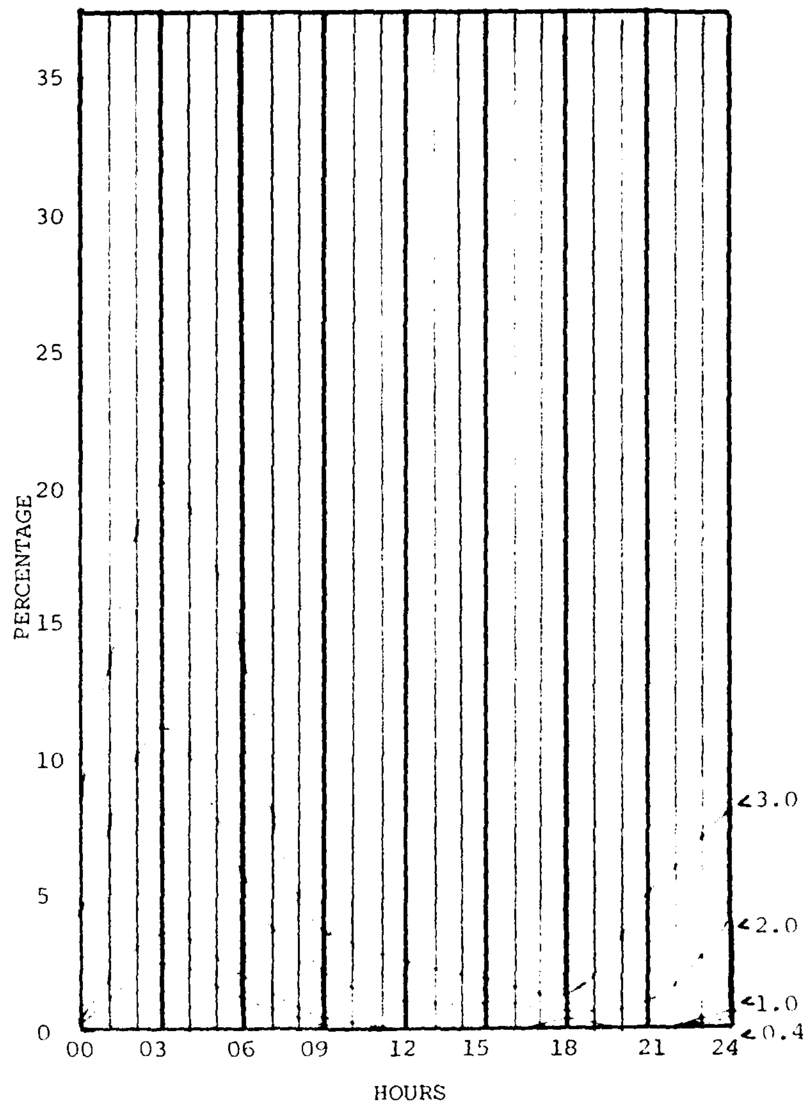

CEILING

MAY

VISIBILITY ( Nautical Miles)

PERCENTAGE FREQUENCY OF OCCURRENCE



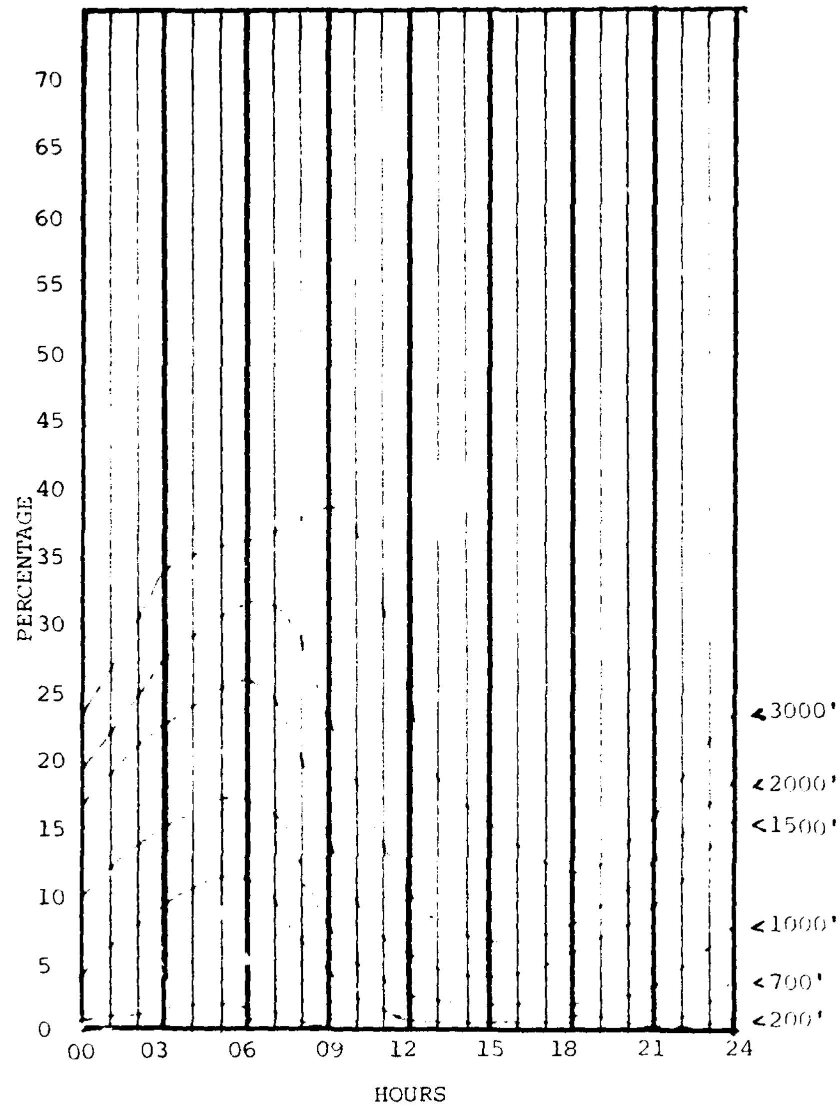



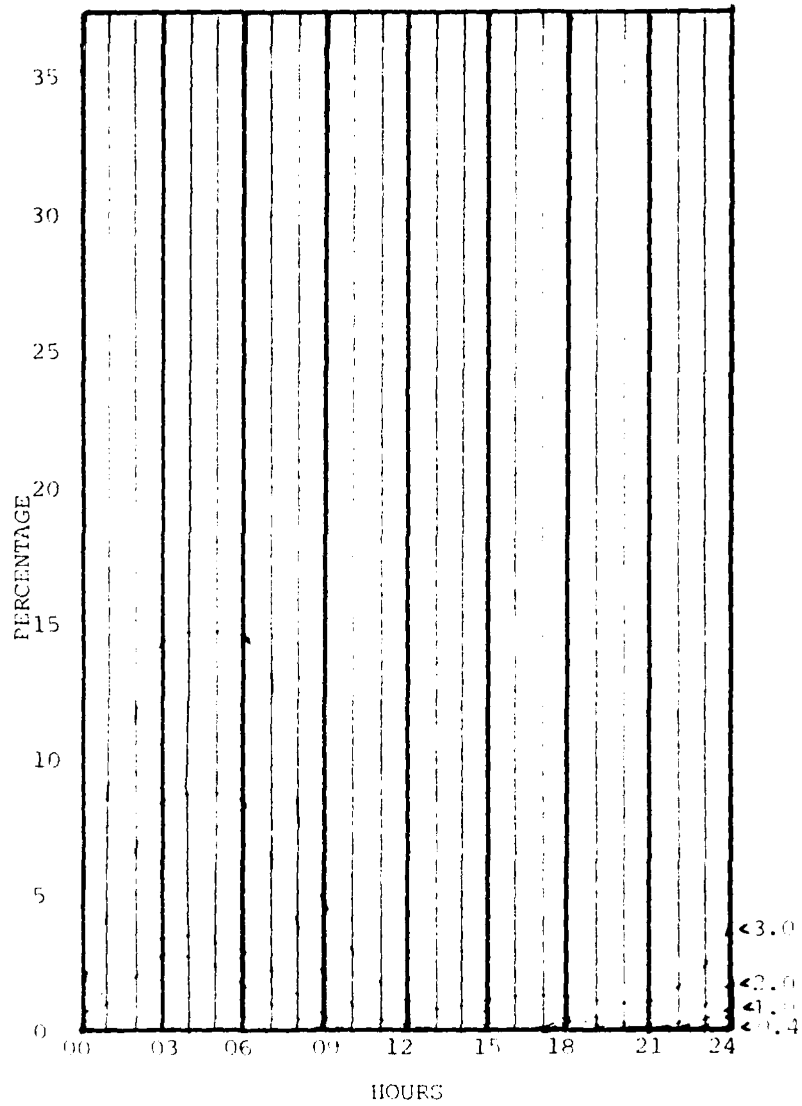

CEILING

JUNE

VISIBILITY (Nautical Miles)

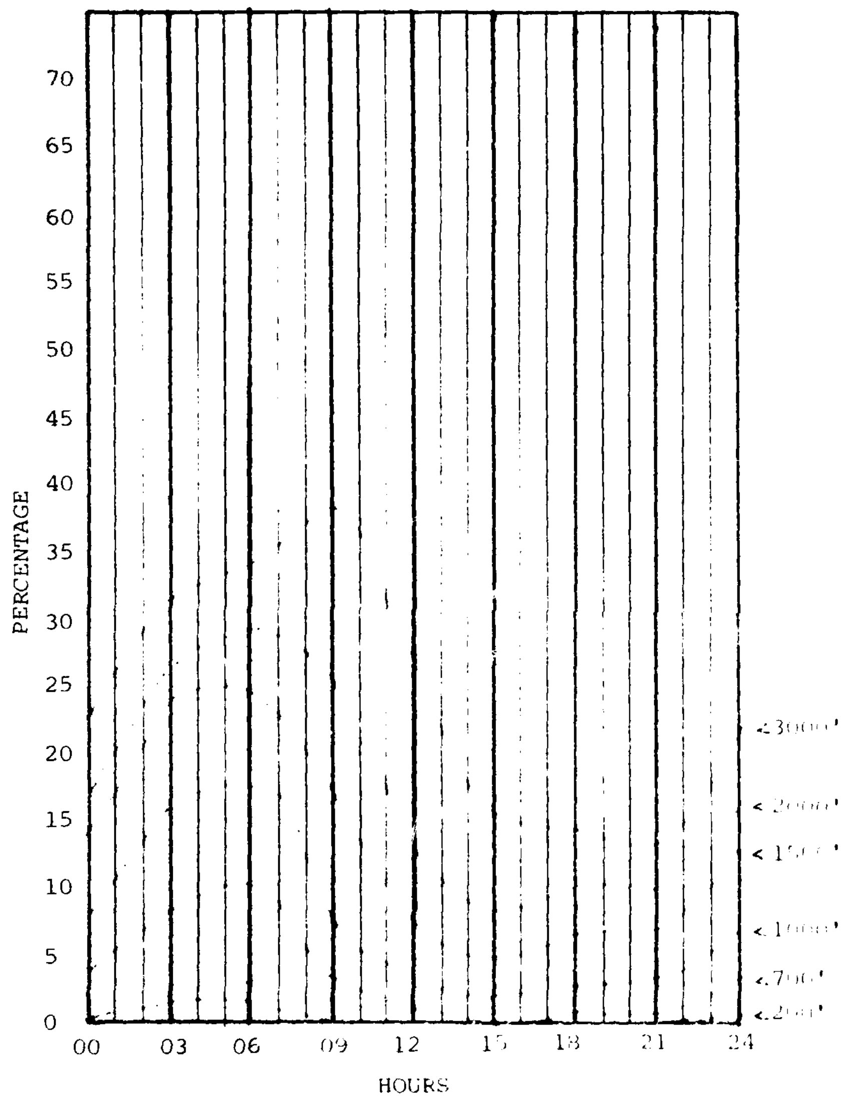
PERCENTAGE FREQUENCY OF OCCURRENCE

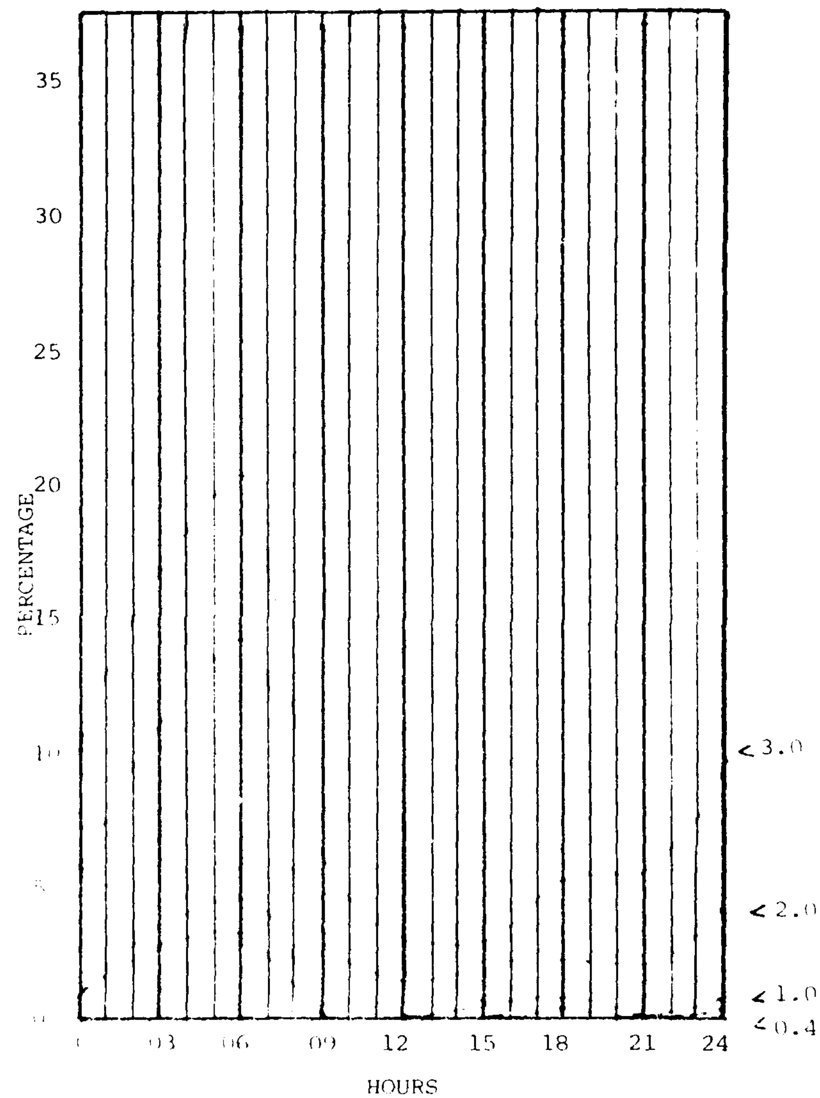



CEILING JULY VISIBILITY (Nautical Miles)

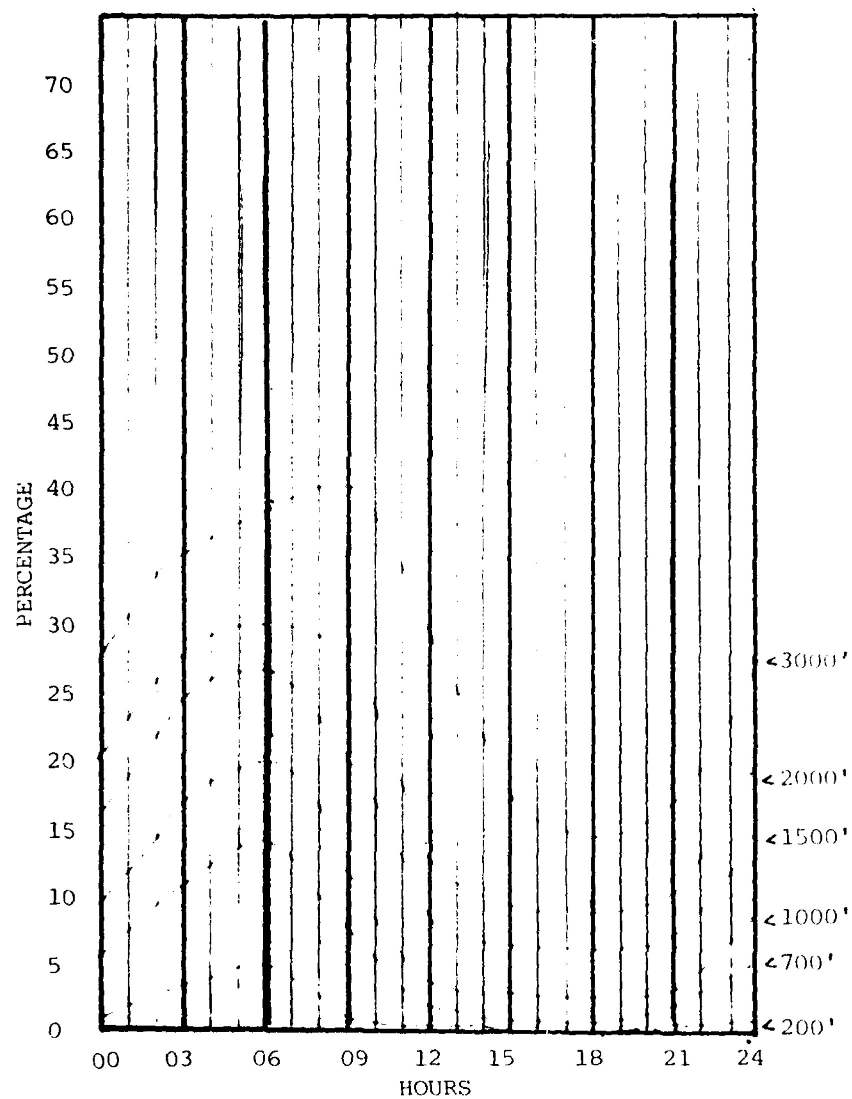
PERCENTAGE FREQUENCY OF OCCURRENCE

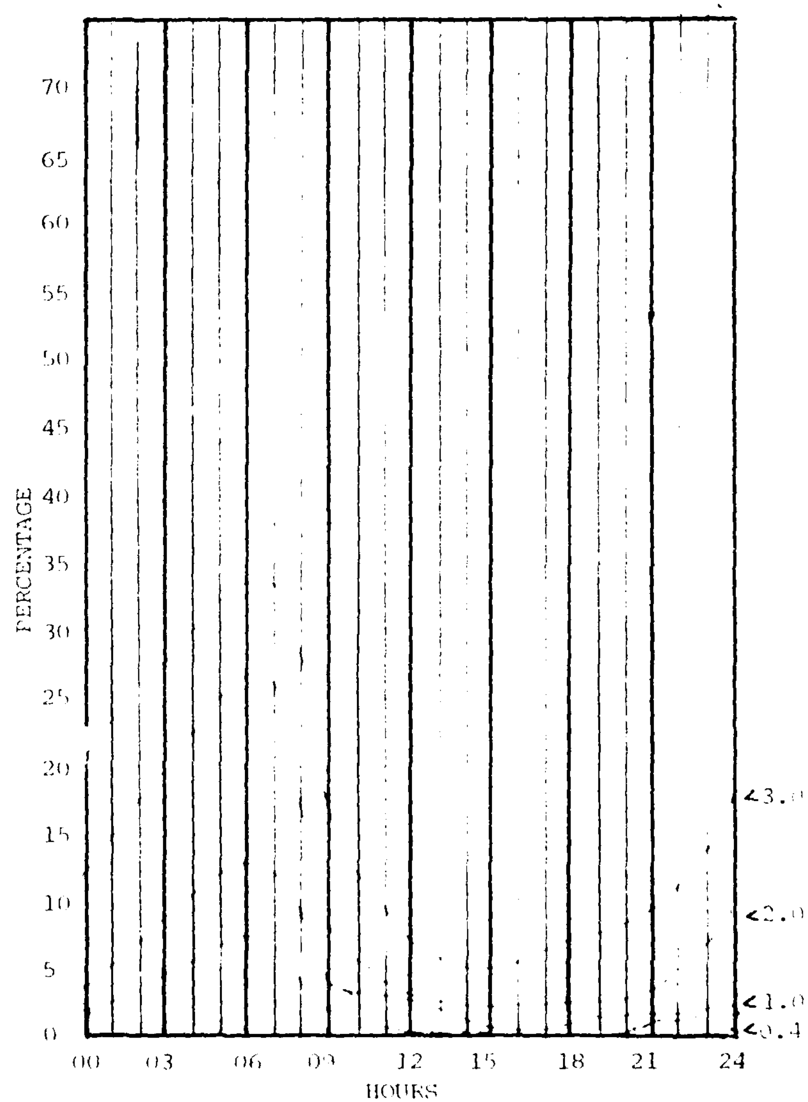



CEILING   AUGUST   VISIBILITY (Nautical Miles)

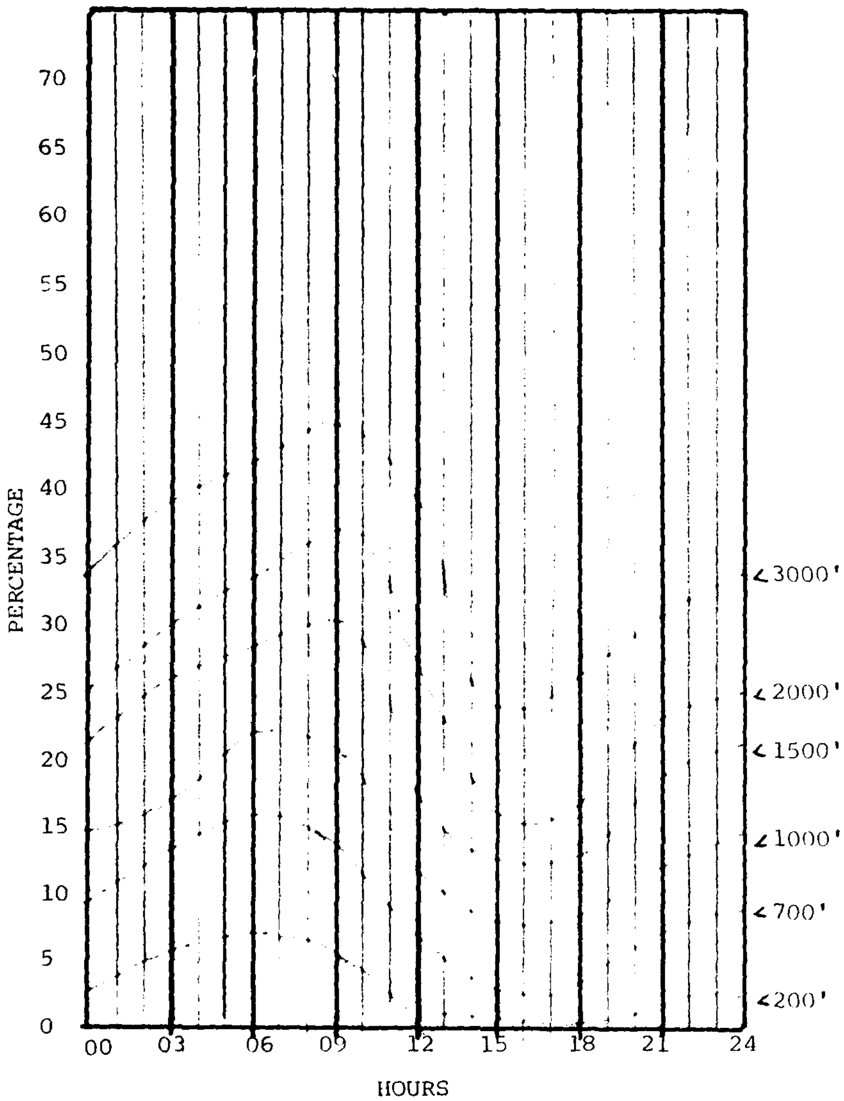
PERCENTAGE FREQUENCY OF OCCURRENCE

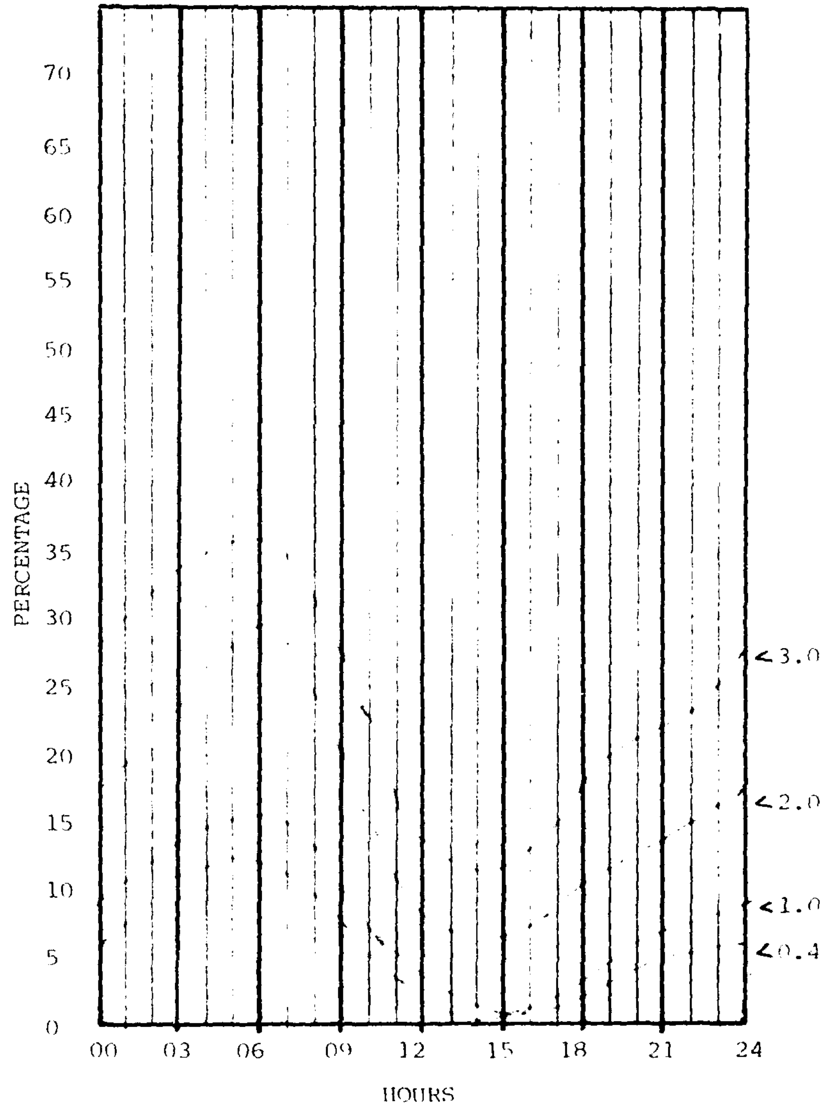



CEILING SEPTEMBER VISIBILITY ( Nautical Miles)

PERCENTAGE FREQUENCE OF OCCURRENCE



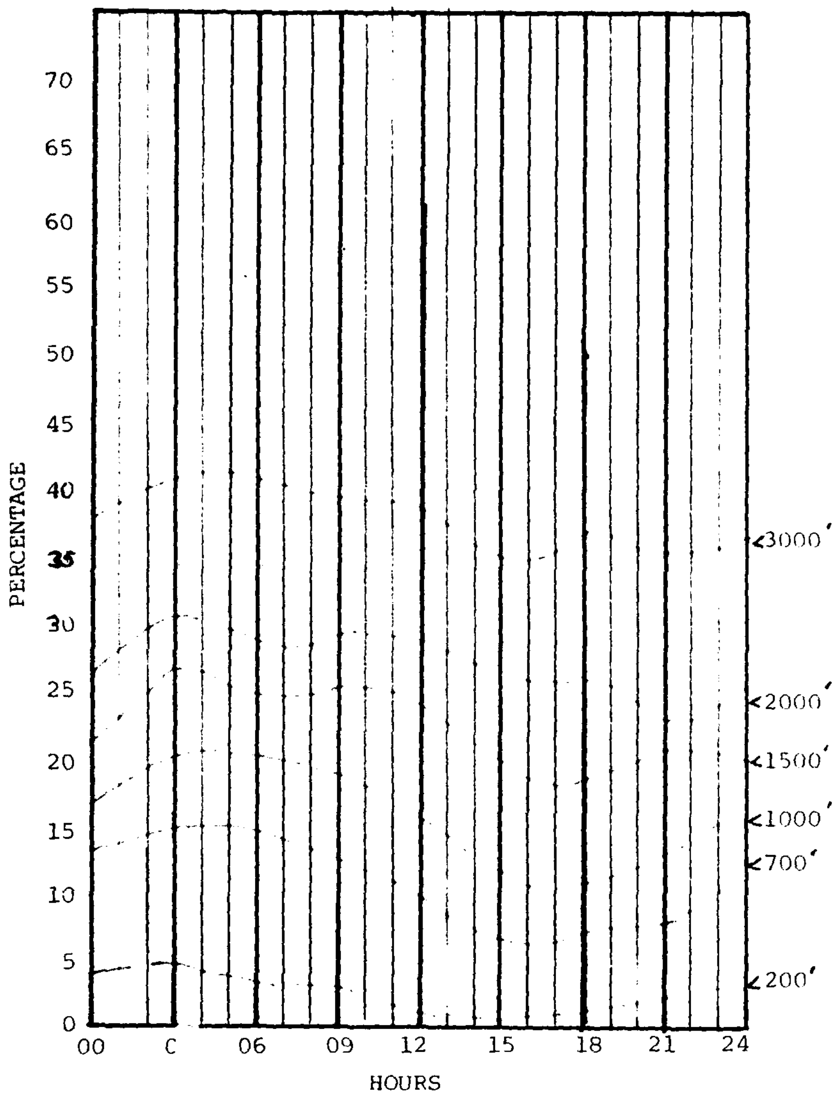



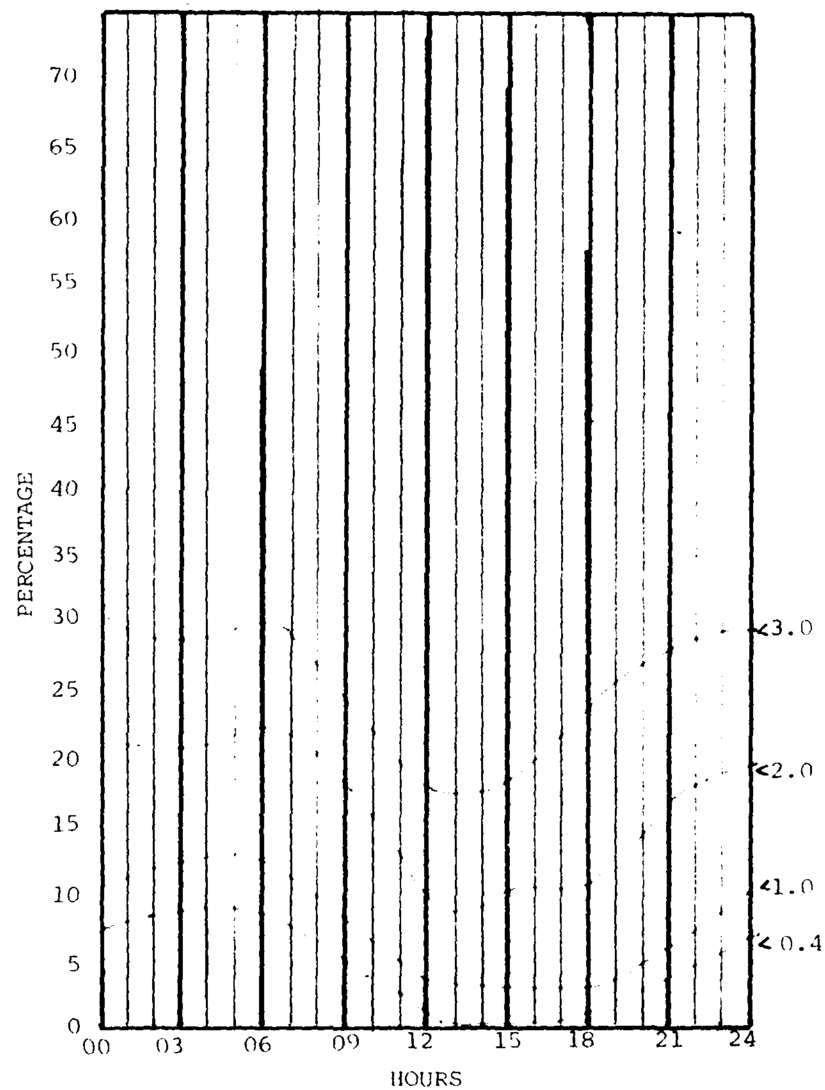

CEILING

OCTOBER

VISIBILITY (Nautical Miles)

PERCENTAGE FREQUENCY OF OCCURRENCE



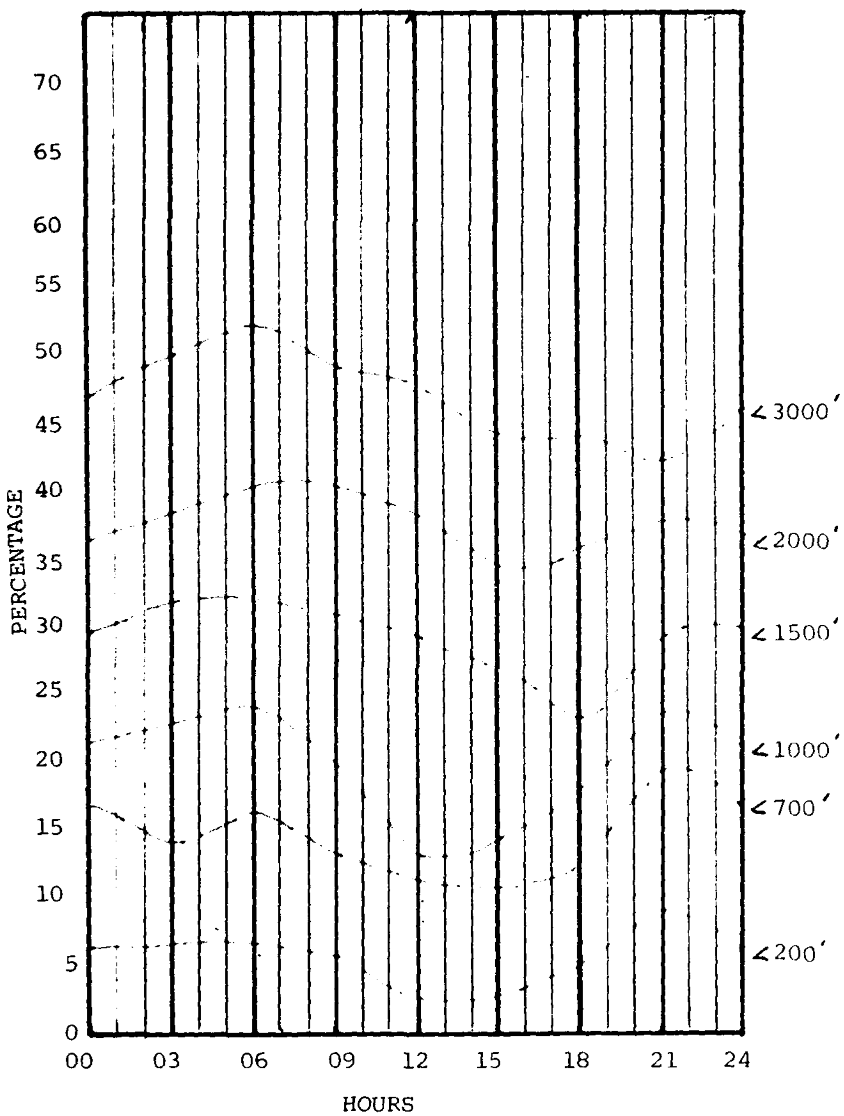



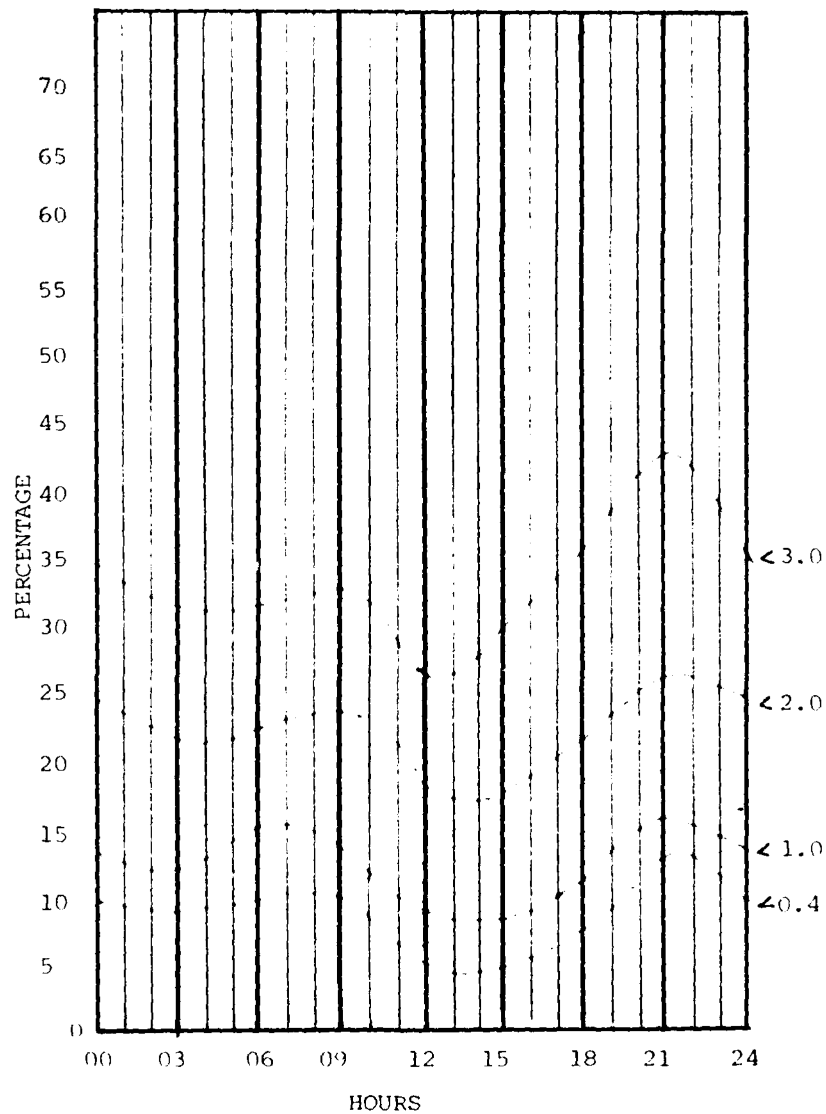

CEILING

NOVEMBER

VISIBILITY (Nautical Miles)

PERCENTAGE FREQUENCY OF OCCURRENCE



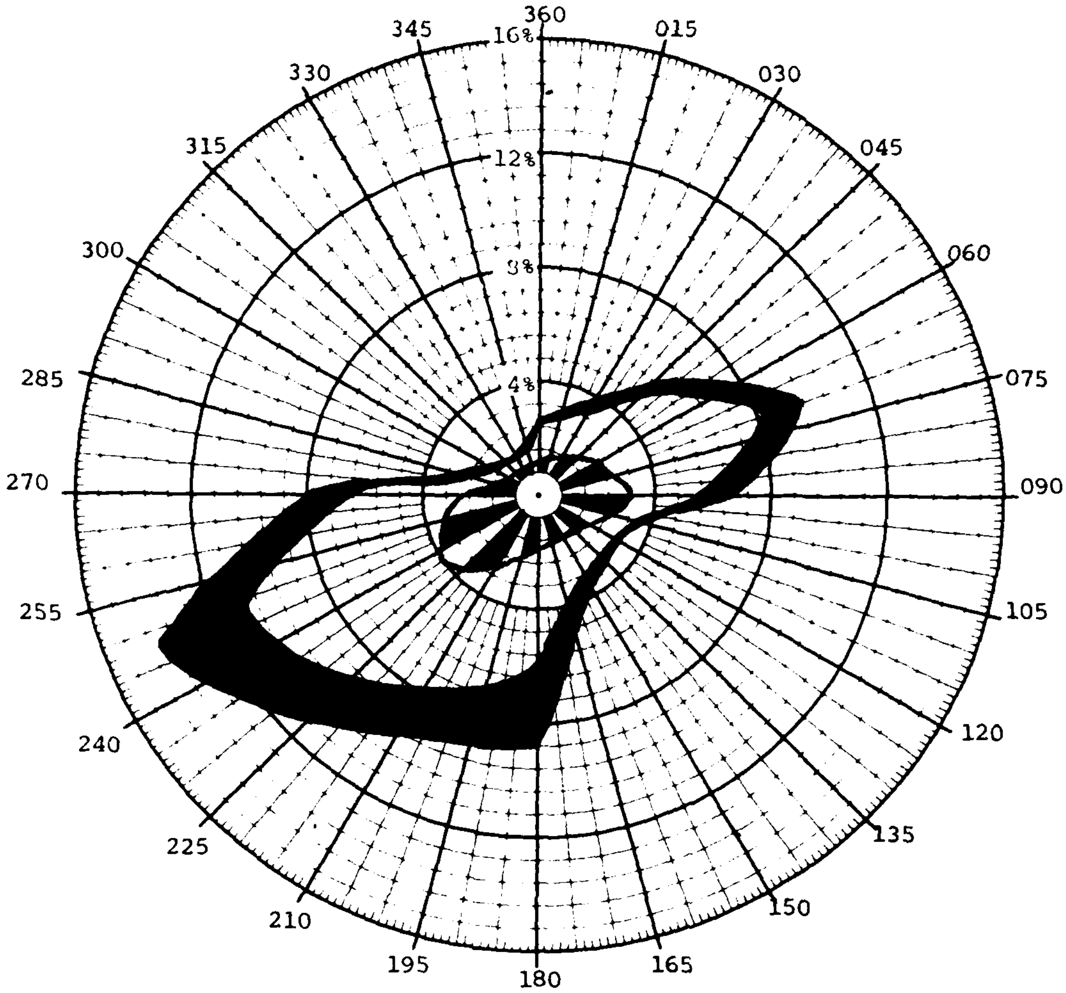




CEILING

DECEMBER

VISIBILITY (Nautical Miles)

PERCENTAGE FREQUENCY OF OCCURRENCE



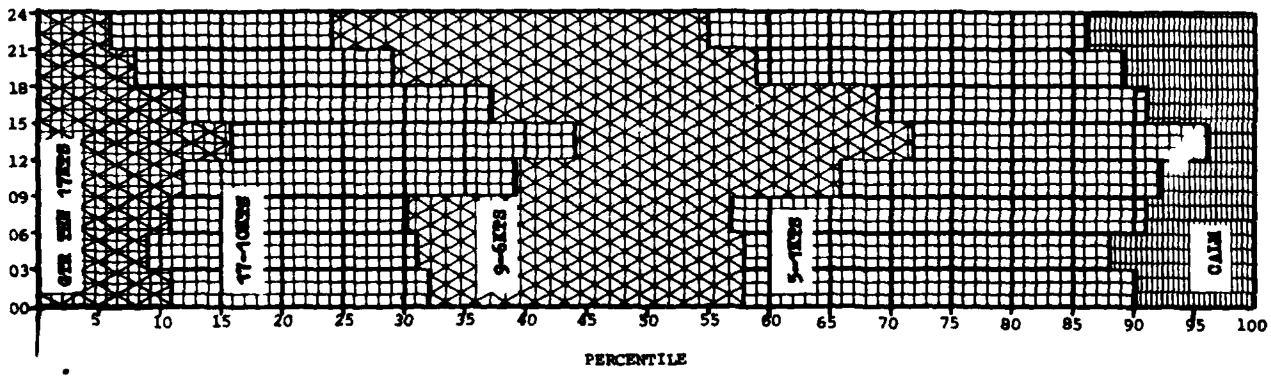

1-6 kts

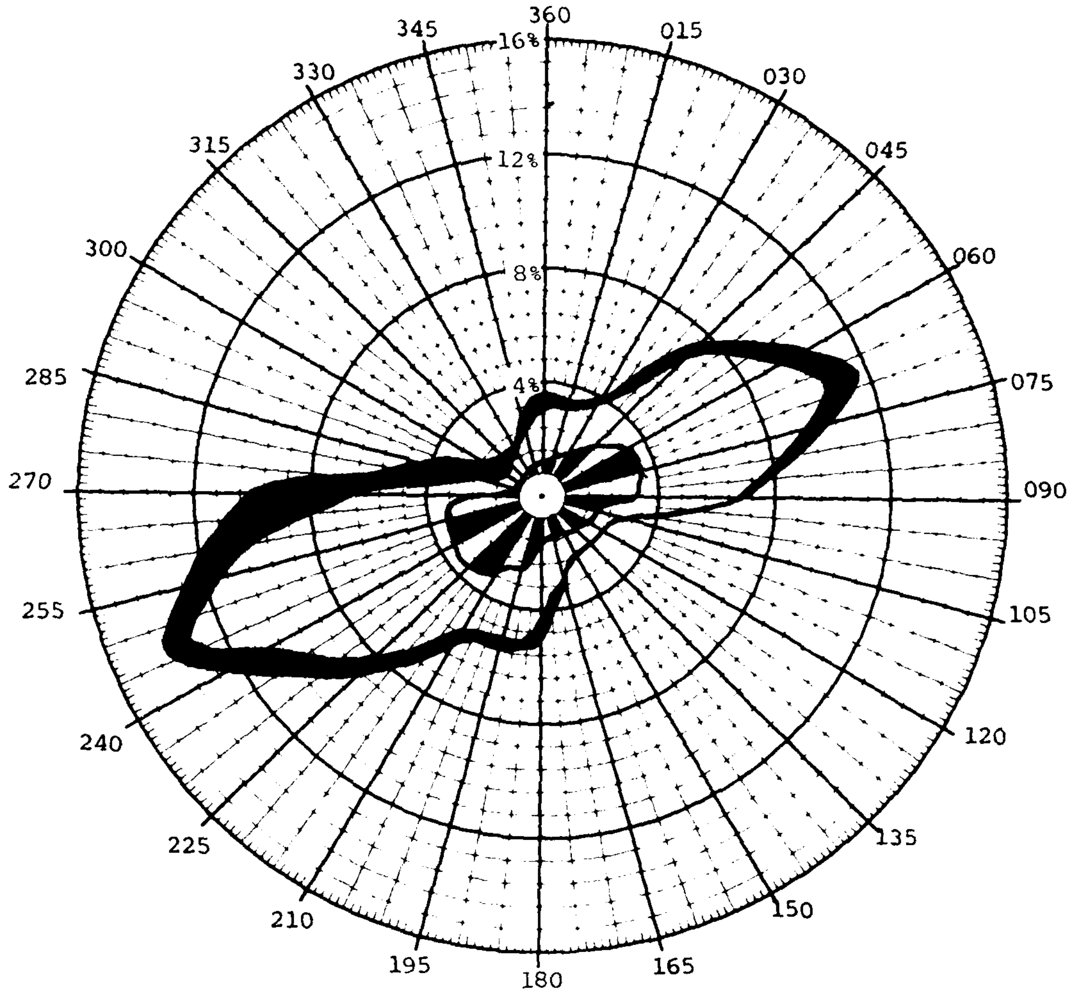
CALM 6.7 %

7-16 kts

JANUARY

≥17 kts





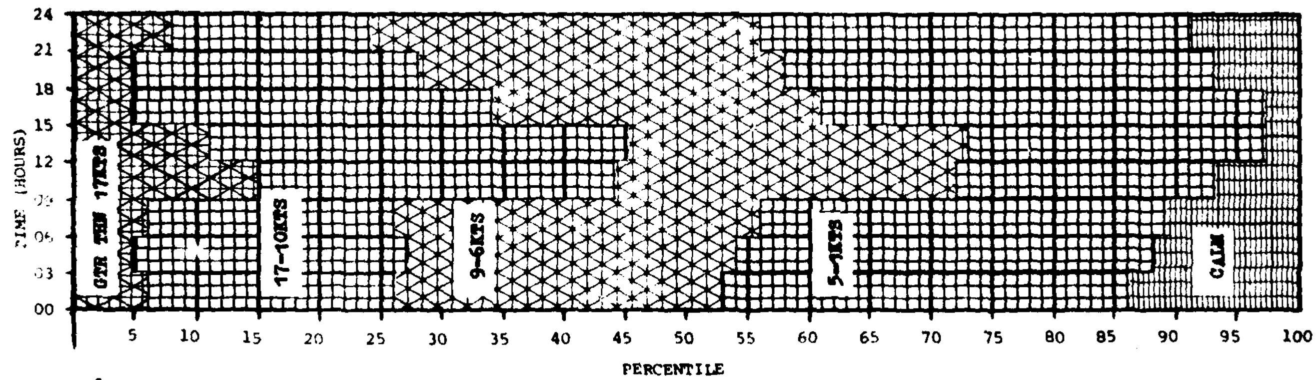

1-6 kts

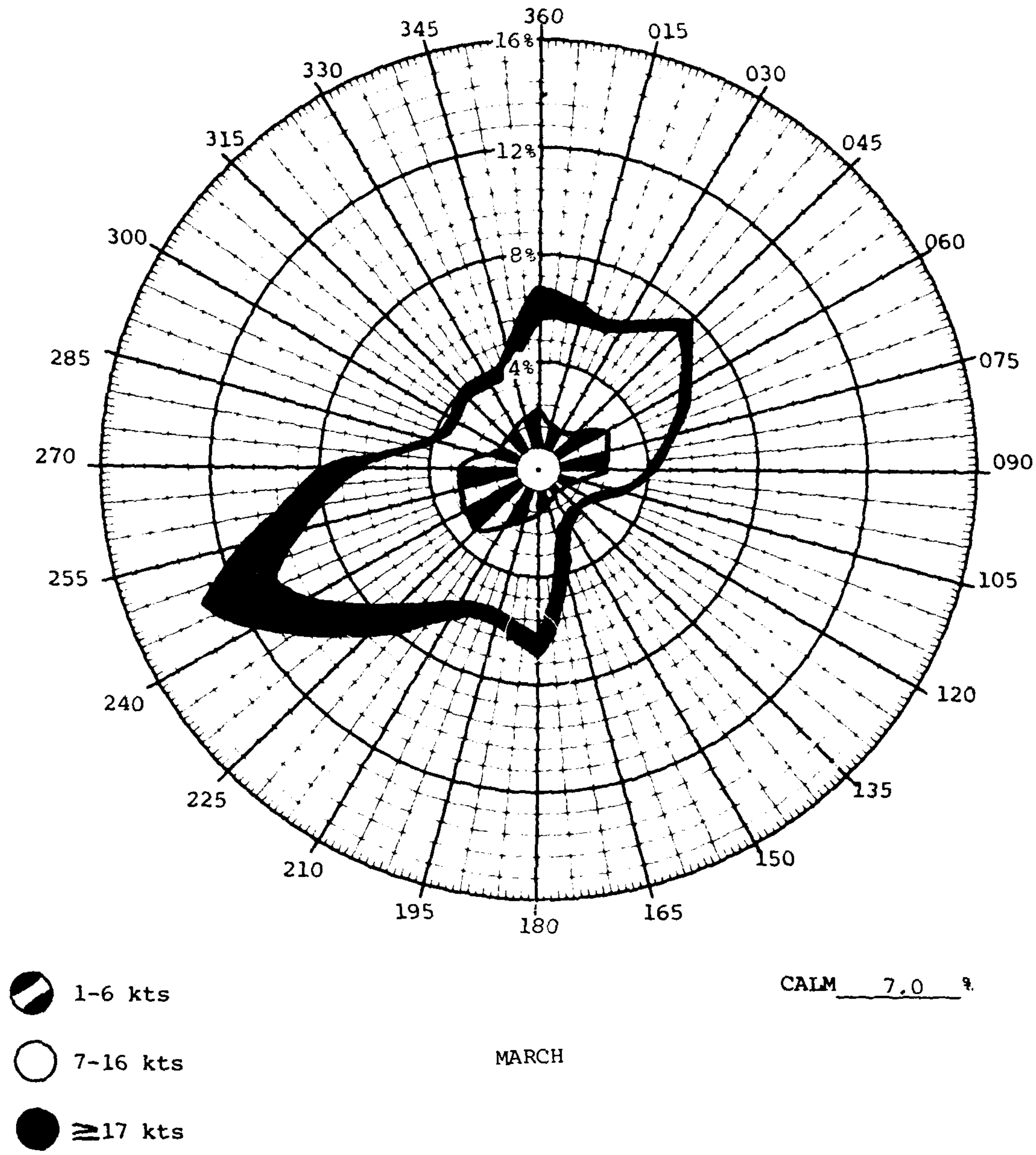
7-16 kts

≥17 kts

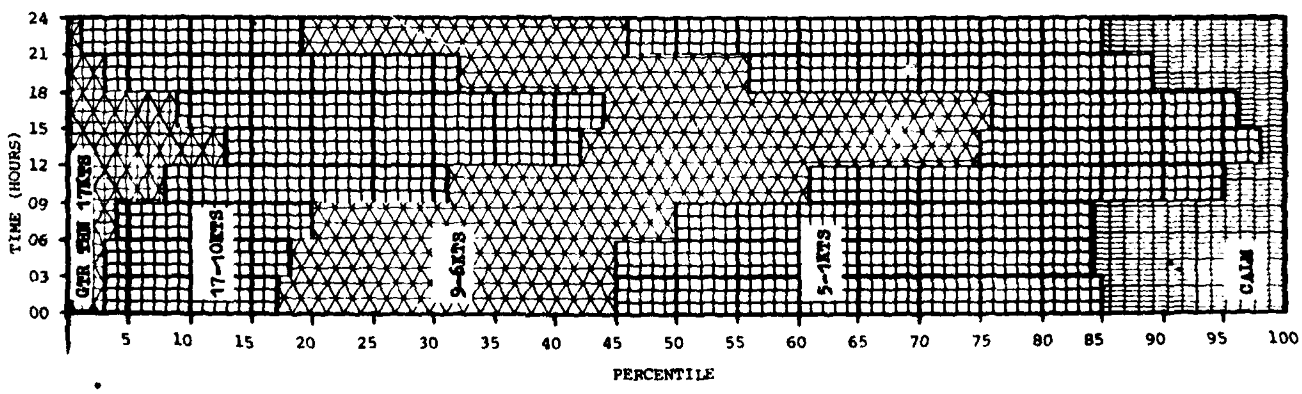
CALM 6.9 %

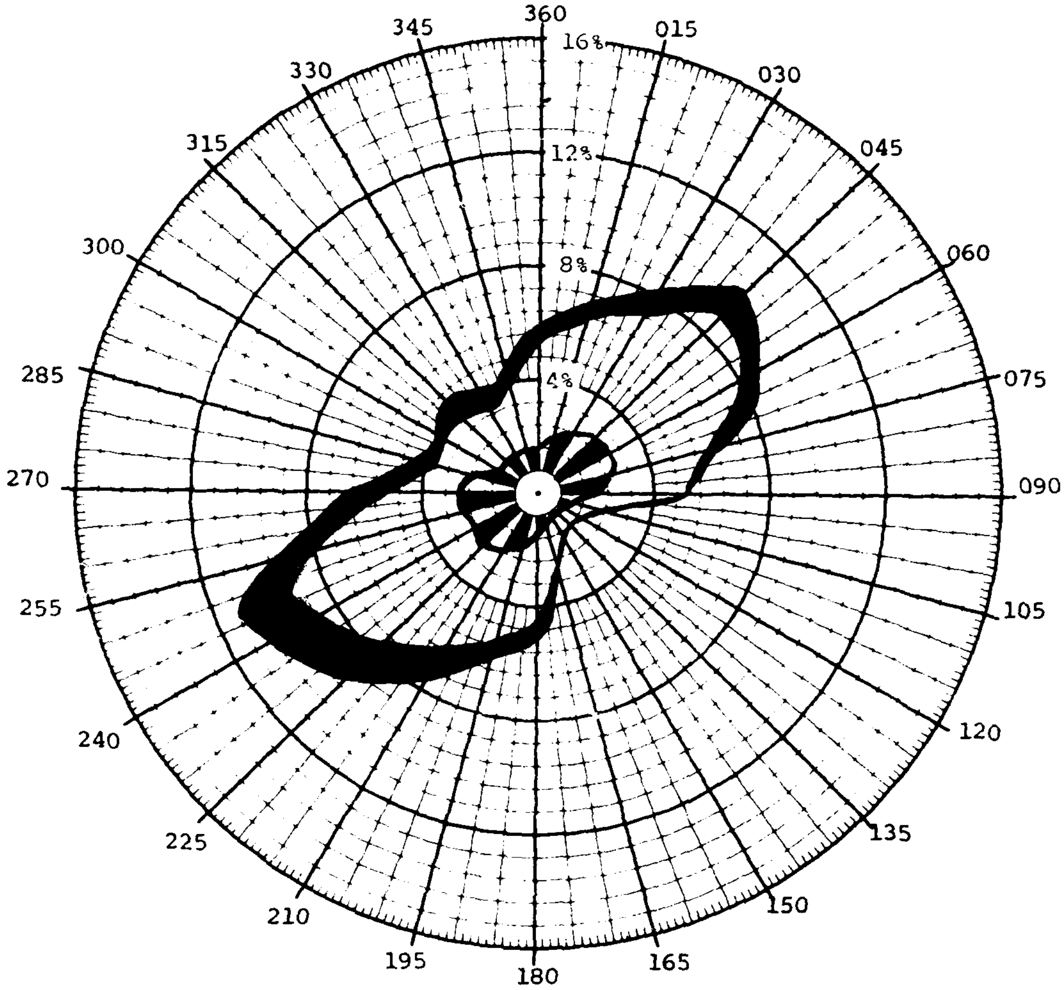
FEBRUARY




360
015
030
045
060
075
090
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
330
345
16%
12%
8%
4%
1-6 kts
7-16 kts
≥17 kts
CALM 7.0 %

MARCH


TIME (HOURS)
PERCENTILE
GTR THN 17KTS
17-10KTS
9-6KTS
5-1KTS
CALM



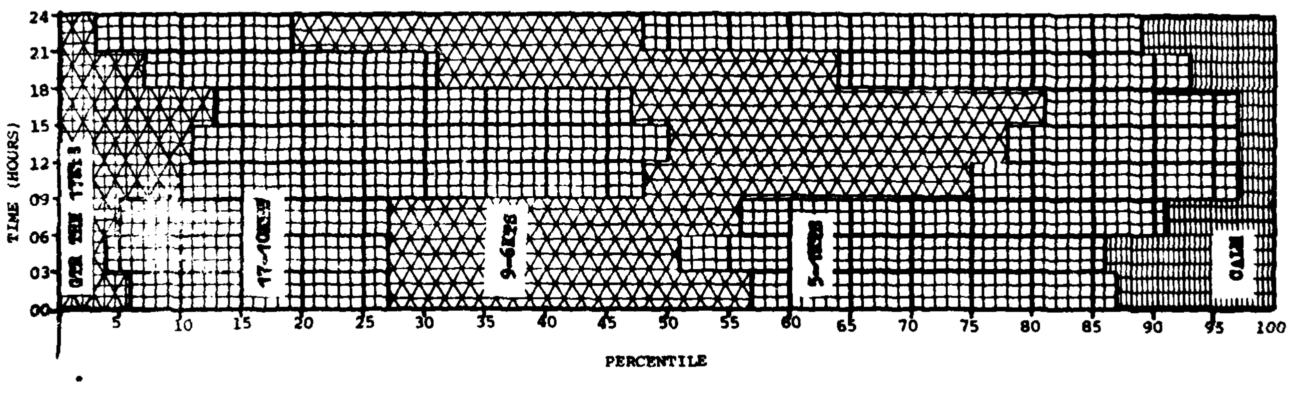

1-6 kts

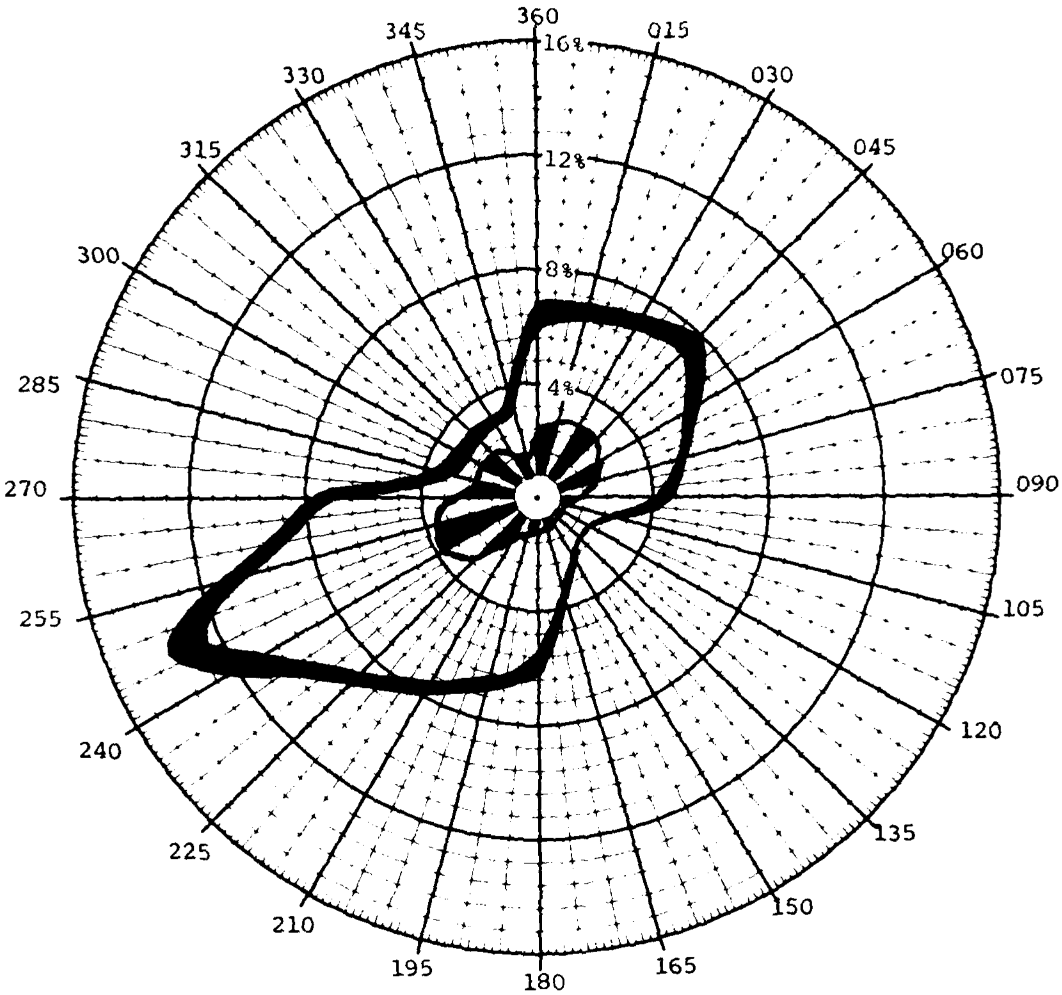
7-16 kts

≥17 kts

CALM 6.4 %

APRIL





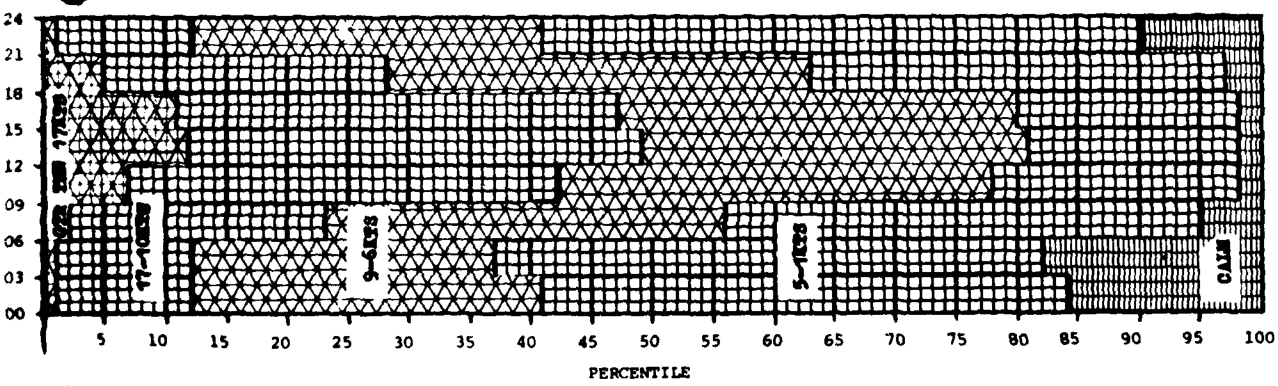

CALM 6.0 %

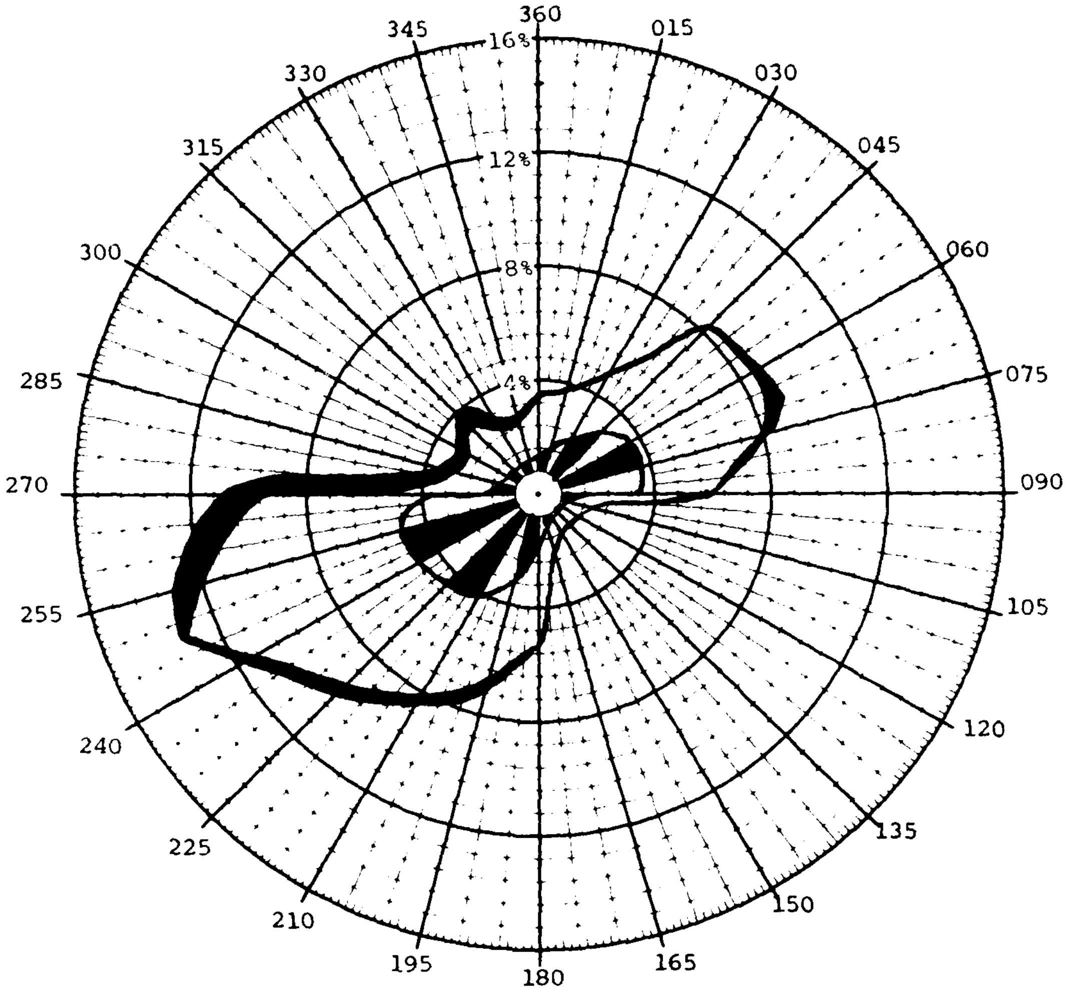
1-6 kts

7-16 kts

MAY

≧17 kts





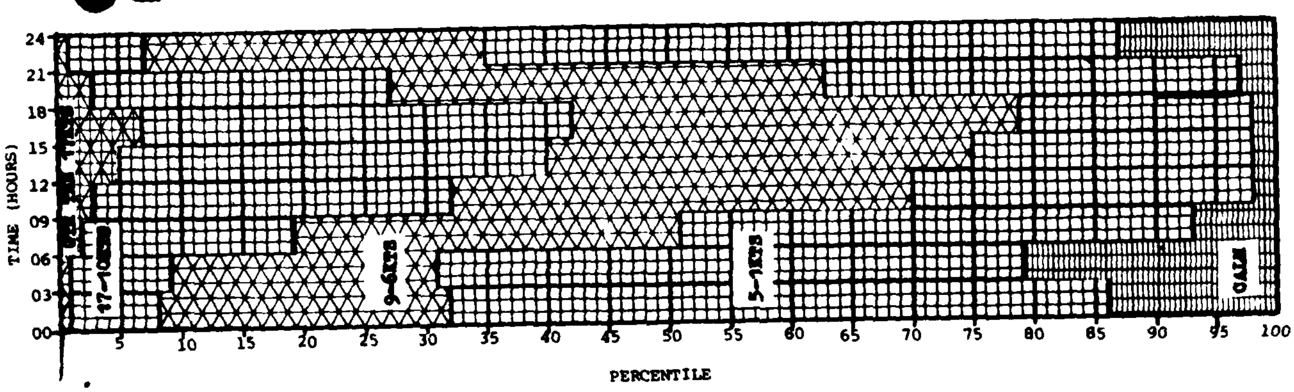

CALM 7.1 %

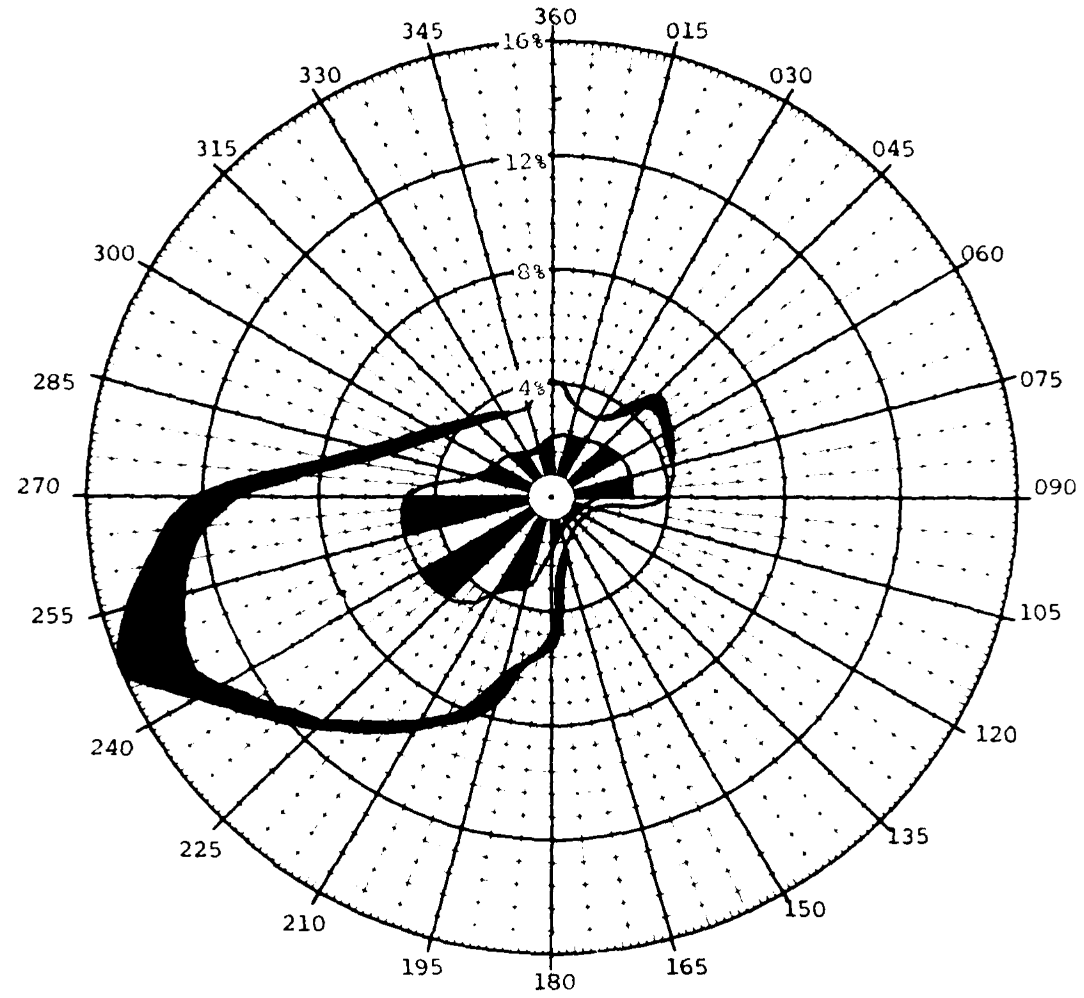
1-6 kts

7-16 kts

JUNE

≥17 kts





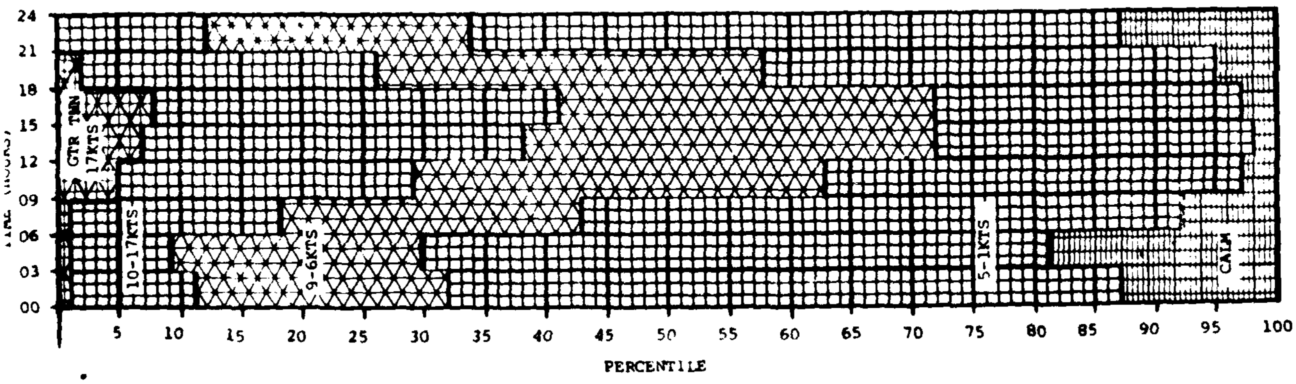

1-6 kts

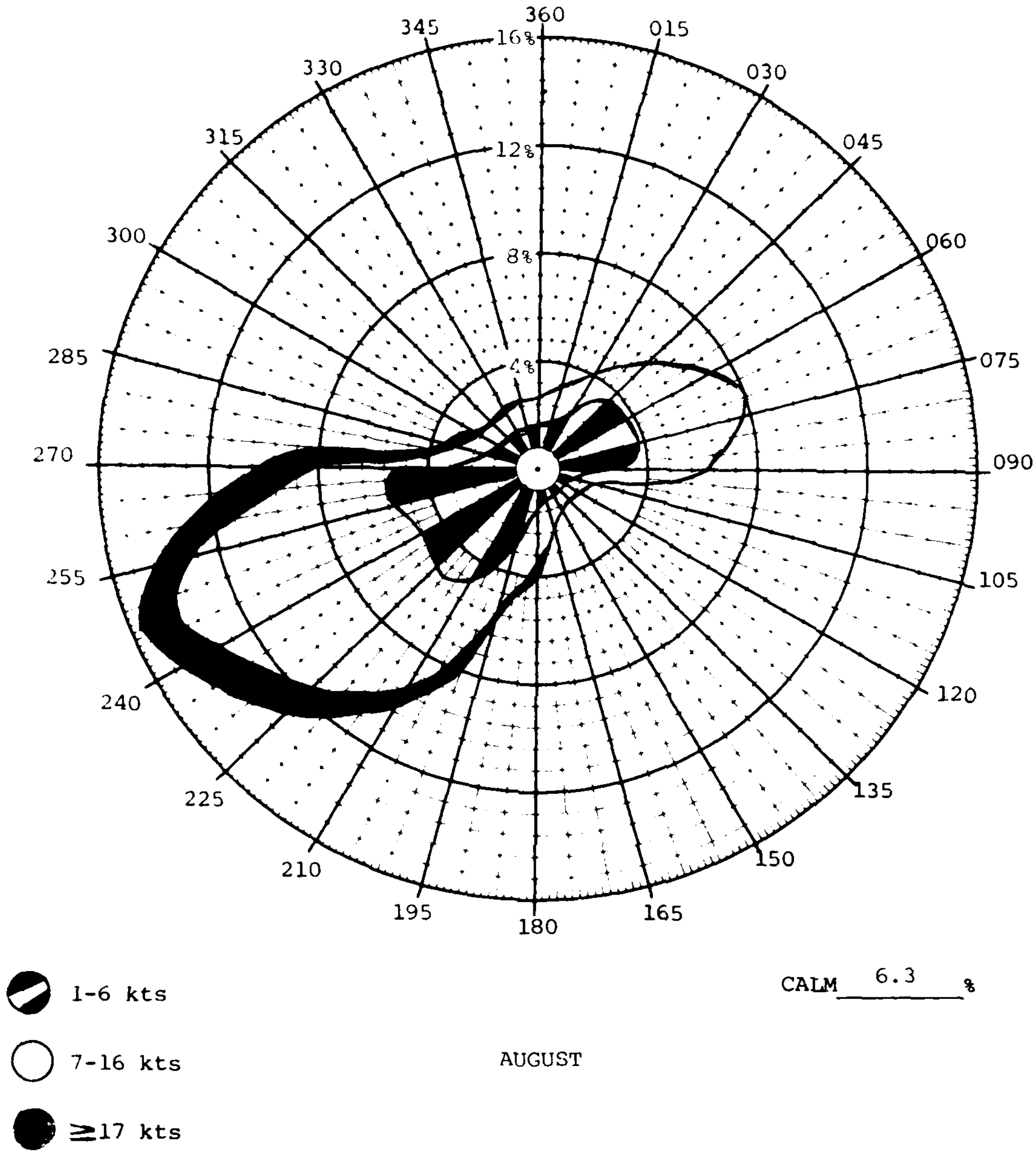
7-16 kts

≥17 kts

CALM 7.3 %

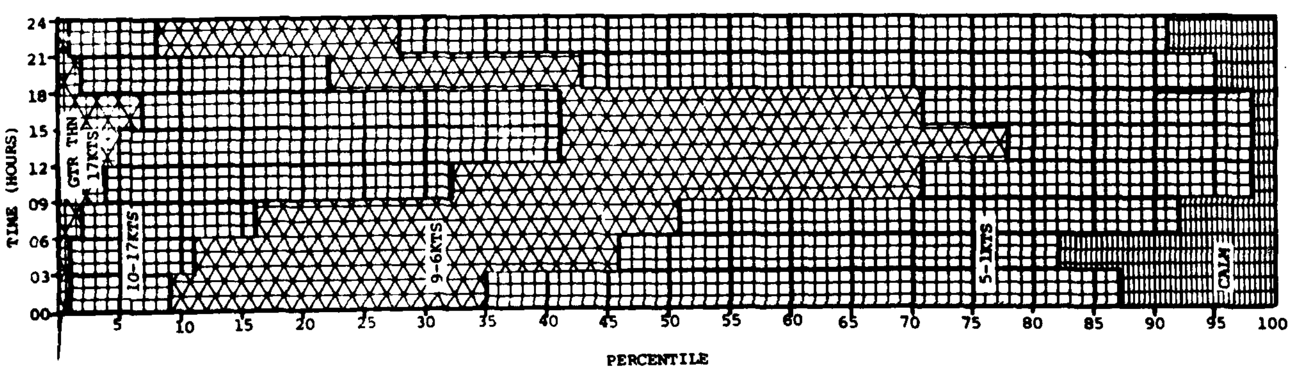
JULY



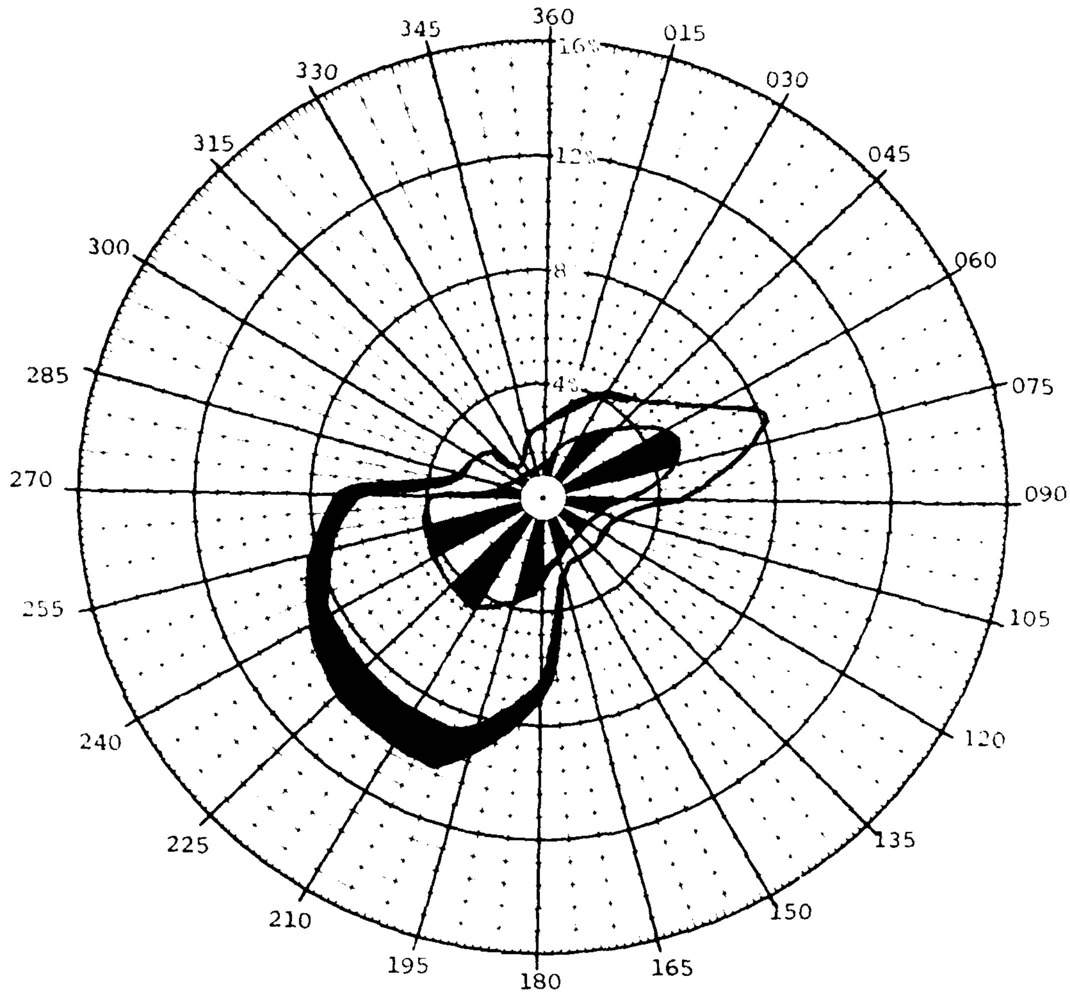


360
015
030
045
060
075
090
105
120
135
150
165
180
195
210
225
240
255
270
285
300
315
330
345
16%
12%
8%
4%
1-6 kts
7-16 kts
≥17 kts
CALM 6.3 %


AUGUST



TIME (HOURS)
24
21
18
15
12
09
06
03
00
GTR THN 17KTS
10-17KTS
9-6KTS
5-1KTS
CALM
5
10
15
20
25
30
35
40
45
50
55
60
65
70
75
80
85
90
95
100
PERCENTILE



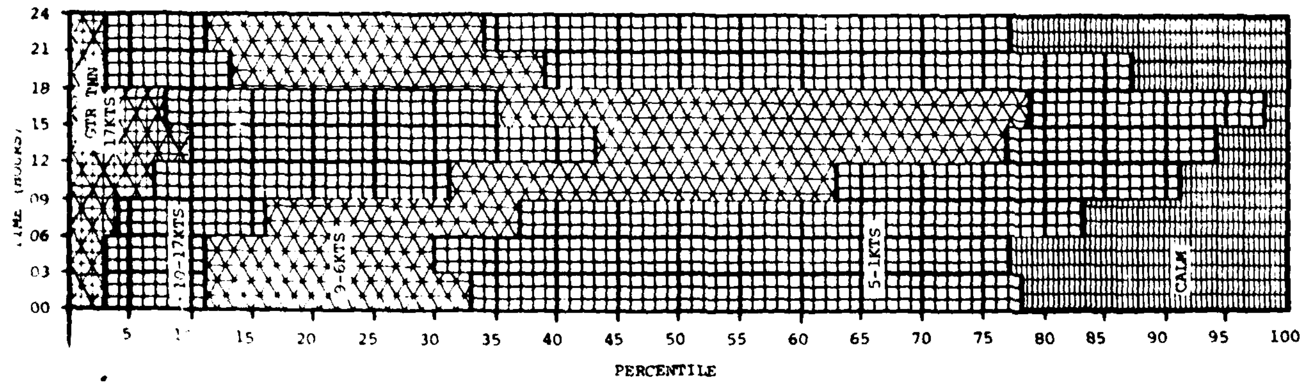

1-6 kts

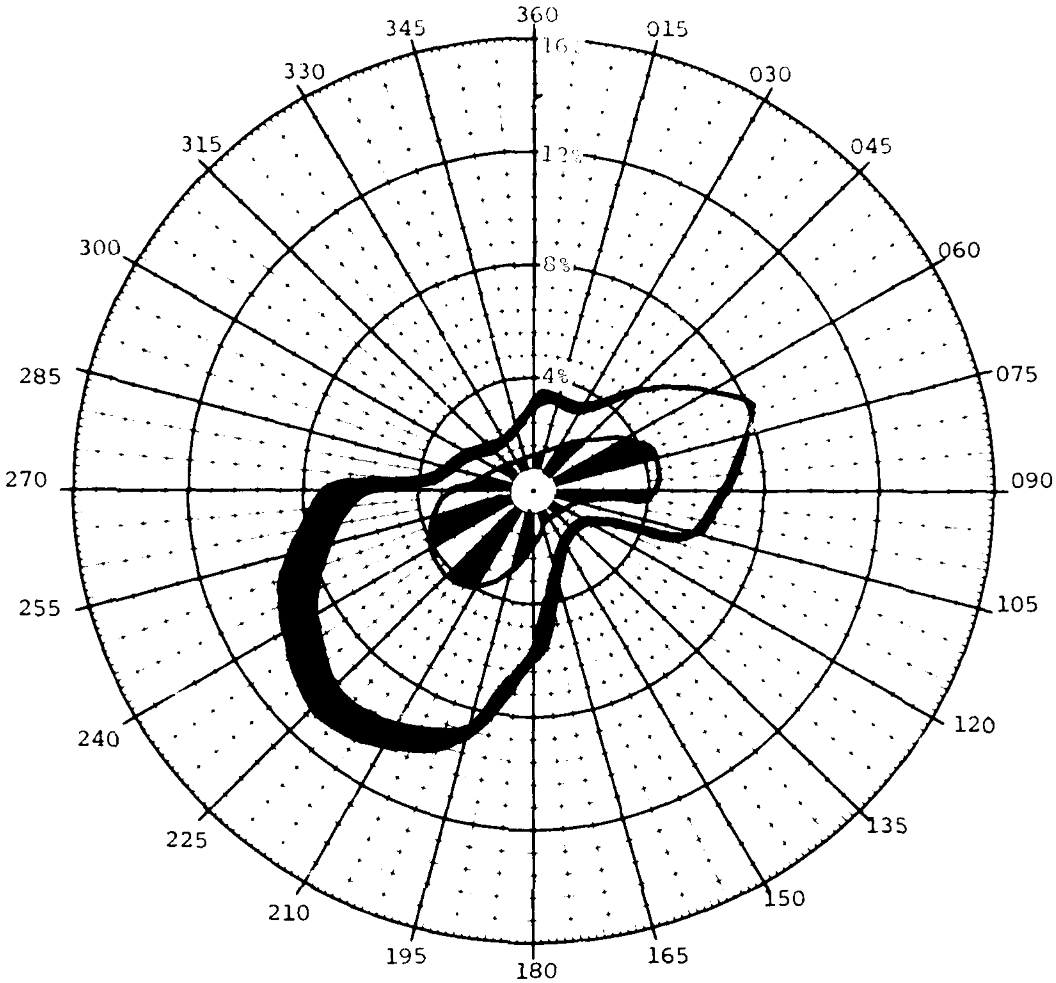
7-16 kts

≥17 kts

CALM 11.6 %

SEPTEMBER





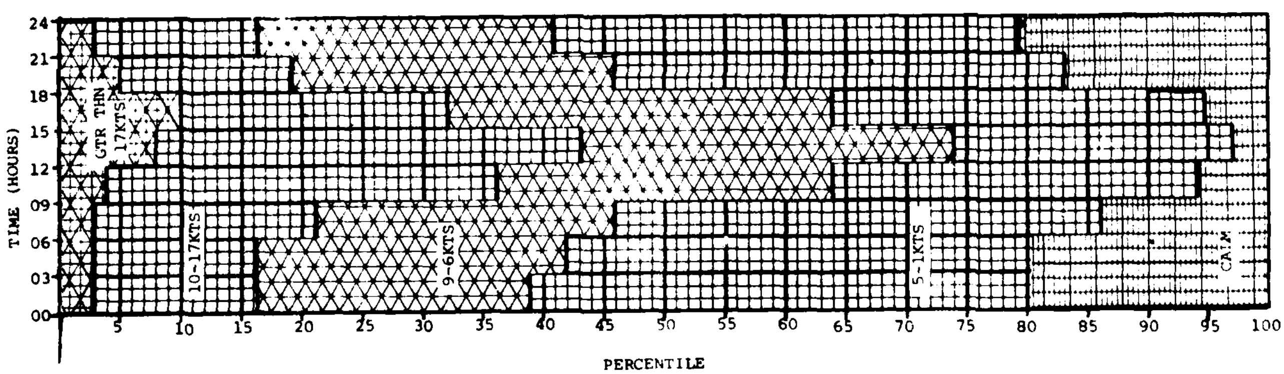

CALM 12.6 %

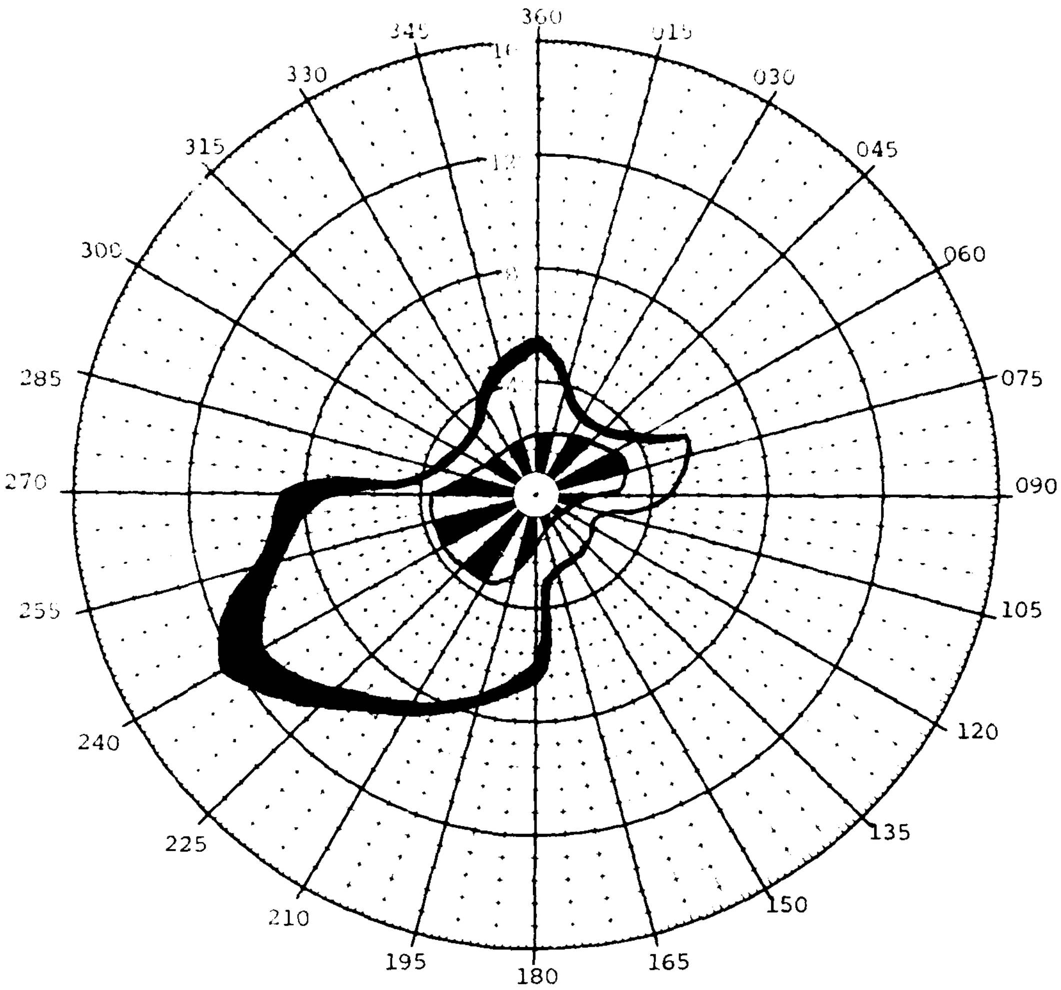
1-6 kts

7-16 kts

OCTOBER

≥17 kts





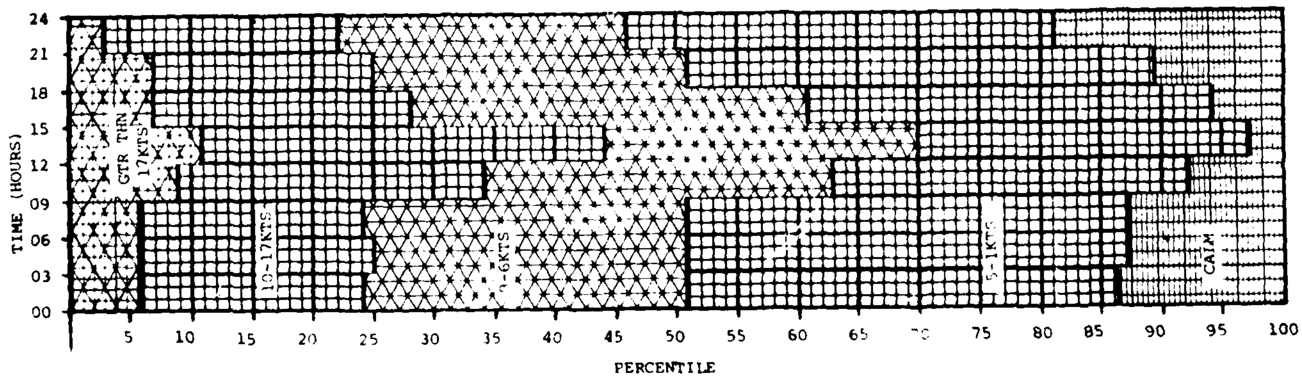

1-6 kts

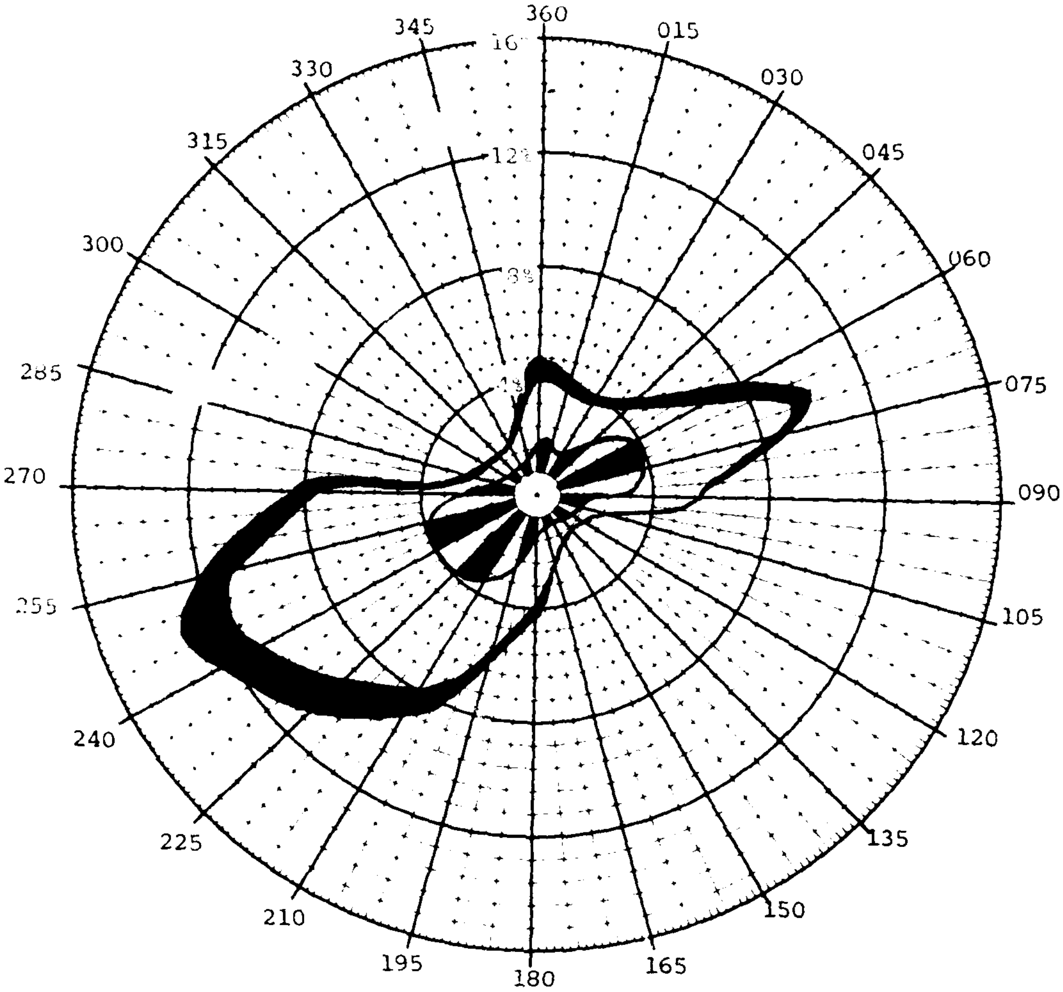
7-16 kts

≥17 kts

CALM 10.4 %

NOVEMBER





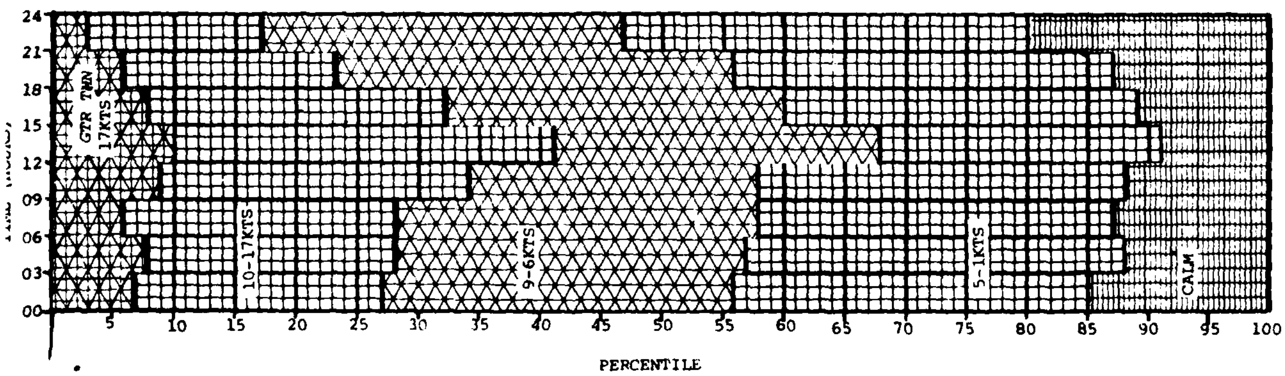

1-6 kts

CALM 11.9 %

7-16 kts

DECEMBER

≥17 kts



# SECTION III

# LOCAL FORECAST STUDIES

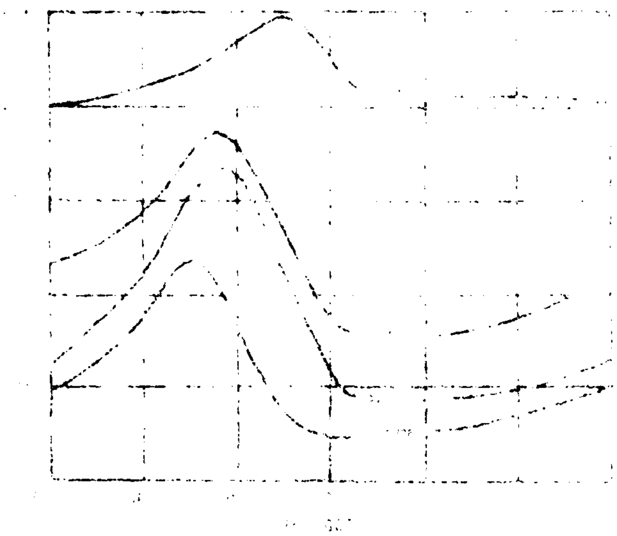


Figure     Frequency of [illegible] 137 feet, September [illegible]

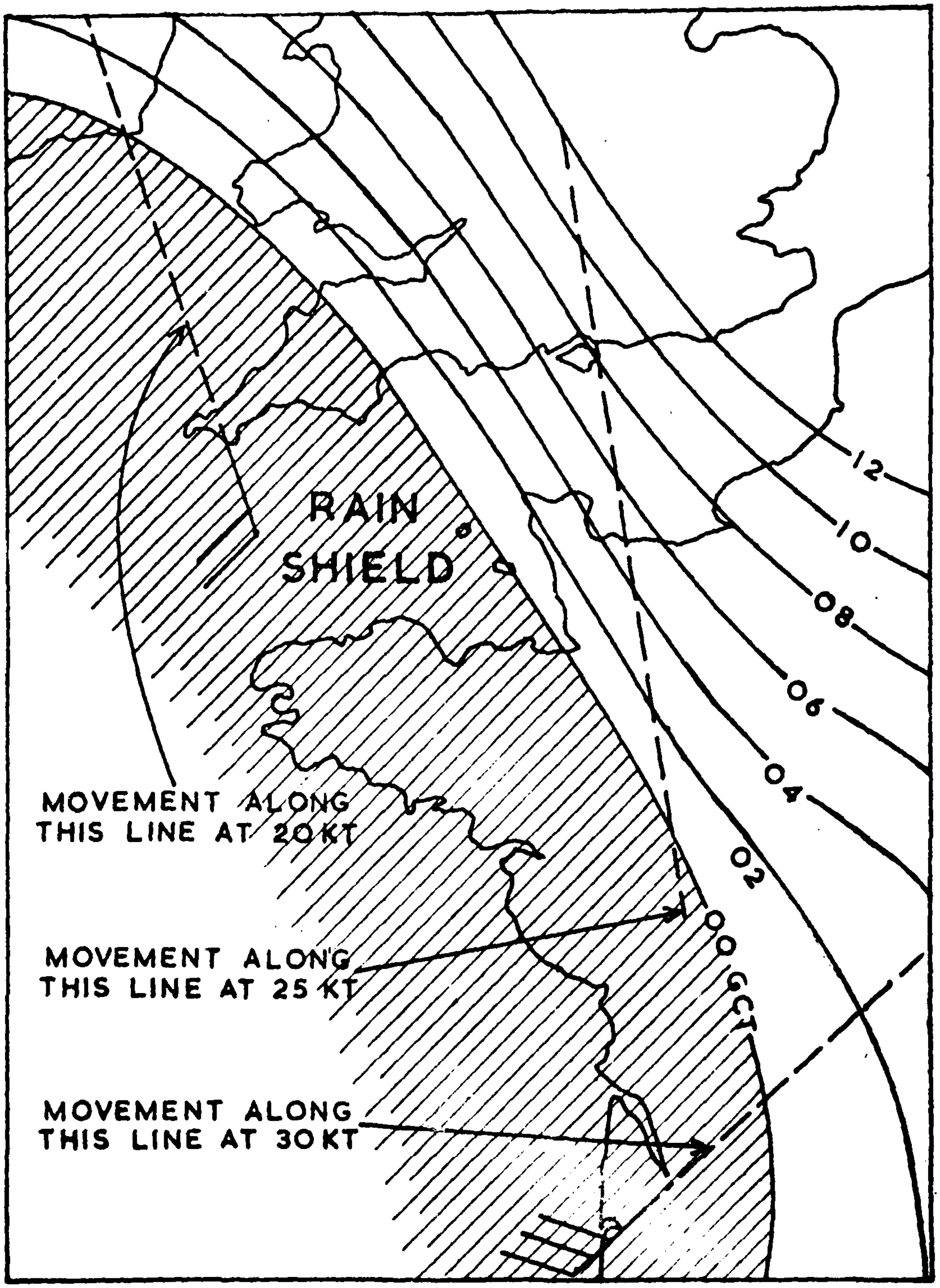



Figure 3. Isochrones of the leading edge of the precipitation shield 14 March 1960. The nimbostratus moves with the velocity of the 700 mb wind in which it is embedded.

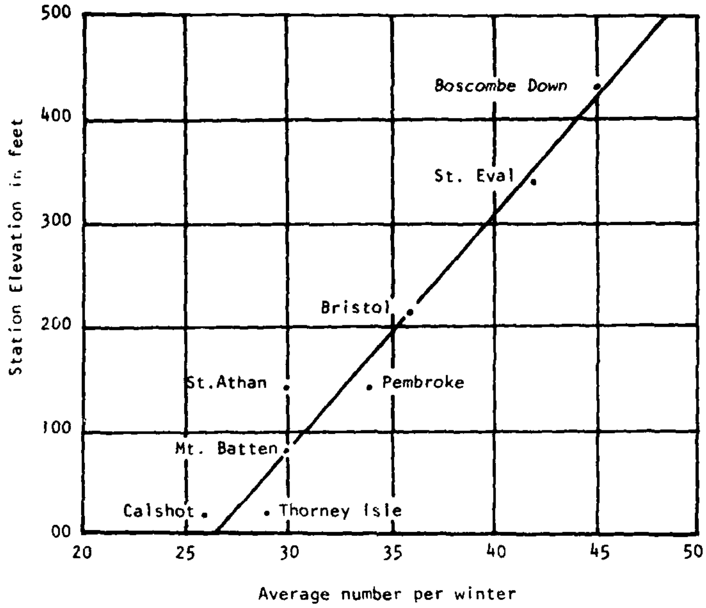



Figure 4. Clouds below 1000 feet at coastal stations, taken from 0100 and 1300 GCT reports, compared with station elevation.

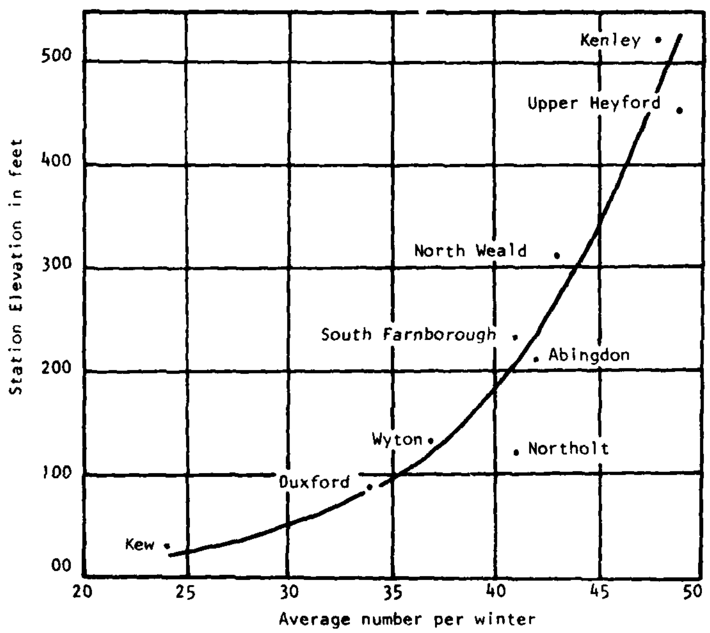



Figure 5. Clouds below 1000 feet at inland stations, taken from 0100 and 1300 GCT reports, compared with station elevation.

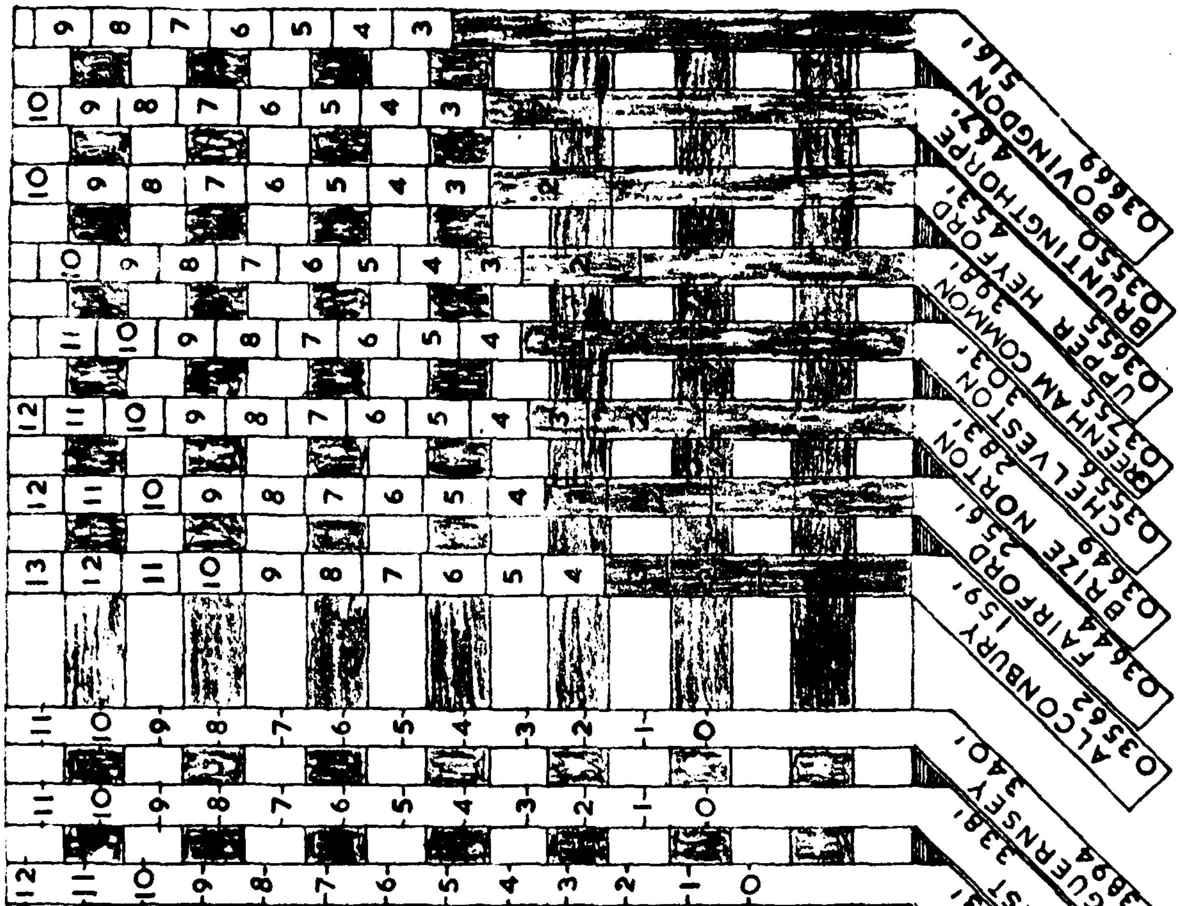


Figure 6. Ceiling computer. From heights reported by left hand stations, go horizontally to right hand group to determine forecast ceilings. All heights are in hundreds of feet.

Rain stratus is by far the most frequent type that affects England, the average annual number of rain days varying from 175 to 225 (2). Most of this rain, especially in winter, is quasi-steady in character and low stratus is readily formed by the evaporation of the relatively warm rain drops in a low cold stratum of air. This implies a strong inversion, often provided over the United Kingdom by warm fronts and occlusions. These are frequently preceded by rain bands extending as much as 300 nm ahead of the surface front. Rain shields with cold fronts are much narrower and seldom persist in place long enough to develop extensive stratus. Rain shields associated with warm and occluded fronts often expand over the British Isles, while those associated with cold fronts seldom do. It is when rain covers a large area nearly uniformly that widespread low stratus ceilings form, providing of course that the low levels are stable. This stability is normal in winter. If it does not already exist, evaporative cooling will establish it, providing precipitation continues more than a couple of hours. It goes without saying that the strength of the wind has a great effect on both the stabilization of the surface layer of air and also on the height of the stratus or fog.

2. The Steering Level

Some two hundred synoptic situations were studied to determine the most useful level and tool in forecasting the advance of quasi-steady precipitation. It was found that the shield is carried so nearly with the 700 mb reported wind within the shield and nearest the leading edge that no adjustment is justified. It is emphasized that this is true even when no cloud at this level appears in ground reports, due to either obscuration or a lower deck of clouds.

In forecasting the movement of a rain shield, the direction of the representative wind must be considered as well as the speed. Obviously, a 30-knot wind blowing 60° from the normal to the leading edge of the rain shield will advance the rain at only 15 knots along that normal. In practice, more accurate results have been achieved by measuring the forecast isochrones in the direction of reported and estimated winds, rather than calculating a speed normal to the leading edge of the rain shield. Figure 3 illustrates a typical situation in which each part of the leading edge moves with the wind in which it is embedded. To forecast these isochrones, the reported speed at 700mb within the rain shield and nearest the leading edge should be used, time permitting, rather than the rounded-off value plotted on the map. When ever two or more representative wind reports are available, the necessity of some adjustment may be expected. Reports may not be strictly simultaneous and some observed irregularities are temporary and unrepresentative. The forecaster must therefore use discretion in the event of conflicting data.

3. Low Stratus

Ceilings of stratus below 1000 feet in rain areas usually form in air strata colder than the falling rain. Cold air is readily brought to saturation and evaporation is little affected by the temperature of the air since the heat of vaporization is furnished primarily by the raindrops themselves. However, the practical meteorologist does not forecast routinely by consideration of physical laws, at least not consciously. A simple rule or approximation is needed for everyday use. Within the limits of practical application, the time interval between the onset of rain and incidence of stratus is the same for all stations in any given situation. This reduces the problem of forecasting the time of rain stratus to that of forecasting the time that rain will begin. If low stratus appears two hours after rain begins at Jersey, it will also appear in the Midlands just about two hours after rain begins there. This rule may seem naive, but we are dealing with a relatively small area where the air is nearly always moist, (3, 4). Whatever the reason, this rule works better than any other yet suggested.

4. Ceiling Heights

The fact that the air in England is relatively uniform can be put to further use. If the incidence of cloud below 1000 feet is compared with station elevation, a positive correlation is found. This appears to be linear for coastal stations, (Figure 4), but not for inland stations, (Figure 5). From this it may be deduced that in any given situation, the height of low stratus above sea level is uniform for the area, except for slight modifications caused by frictional turbulence over inland areas (5). Based on these ideas, a year's data were tabulated and the ceiling computer shown in Figure 6 was constructed. In this graph, the coastal or reference stations are grouped to the left and the stations for which forecasts will be required are grouped to the right. When the first report of stratus is noted, as a rain shield approaches from a southerly or westerly direction, a horizontal line is drawn across the chart from the point representing the report. The height of ceiling to be forecast for each station, when the rain shield and its associated stratus move over the area, is read directly at this line. For example, if Plymouth reports stratus at 800 feet, then 600 feet would be forecast for Brize Norton and 400 feet for Bruntingthorpe. Similarly, a report of 500 feet at Jersey will lead to a forecast of 600 feet at Alconbury and 300 feet at Bovingdon.

The ceiling computer shown in Figure 6 has been operationally tested. It is quick and easy to use and accurate for situations with surface winds of ten to twenty knots. In the few rain stratus cases having winds outside this range, it appeared that adjustments were in order. Stronger surface winds make the ceilings higher and weaker ones let the ceilings descend to lower values. Such cases were too few to determine exact rules for quantitative adjustment.

5. Termination

Low stratus ceilings of the type here considered break soon after the rain stops. Normally the passage of a surface front clears both the rain and the stratus ceilings. In these cases, the usual procedures for forecasting the movement of fronts (6) are applied to determine the time of clearing.

In the majority of cases, the rain shield and its associated stratus march steadily across England and the forecast is guided by evenly spaced isochrones, such as are illustrated in Figure 7. The rain shield and stratus commonly expand in size for the leading edge moves with the velocity of the 700mb winds while the clearing line moves more slowly. On the other hand, there are times when a blocking high will cause the leading edge to decelerate, sometimes stop, and occasionally even retrogress. In these cases, the rain and stratus areas will either maintain their size or shrink. In such situations, e.g., 18 March 1960, (Figure 8) meticulous streamline analysis at 700mb is probably the best tool to determine the future of the rain and stratus patterns.

A blocking high and its associated line of streamline convergence will of course be quasi-stationary. If the rain shield and the 700mb streamline analysis are superimposed, as in Figure 8, the problem may be clarified, or at least better defined. Obviously, if the streamline convergence line lies downwind from the area of interest, it will not affect advection to this region and the forecast will follow regularly spaced isochrones as before. If the streamline convergence line is found upwind, between the rain shield and the area of interest, then the rain and its stratus can hardly reach the region, unless the convergence line cane be forecast to move away. In Figure 8, the line of convergence lies on the western fringe of the Midlands.

England is so situated in the prevailing westerlies that winds from an easterly direction usually bring dry air from the Eurasian continent. When the flow is from the North Sea, then England lies on the side of the anticyclone having considerable subsidence and again the critical levels will be dry. This makes the 700mb streamline convergence line capable at times of stopping the advance of the rain shield abruptly.

While the presence of a blocking high is easy to detect, there is always an area of uncertainty as to the exact location of its associated line of convergence. When this line lies across or near the area of interest, as in Figure 9, its precise location becomes of prime importance. It is best found by drawing two sets of isochrones and locating the convergence line at the intersection of simultaneous isochrones.

In Figure 9, the line of hollow circles is the forecast position of the leading edge of the rain shield in 15 hours and also the forecast leading edge of dry air in 15 hours. To determine the latter, it is necessary to analyze the 700mb chart for humidity. The 50% relative humidity isopleth is the critical one and for practical purposes this may be drawn at 10C temperature-dew point spread. On this isopleth, or on the drier side of it, wind reports must be found pointing toward the area of interest, in our case the Midlands. In a manner quite analogous to determining the movement of the rain shield, isochrones are constructed showing the movement of the dry air, i.e., the air with 50% or less relative humidity. The convergence of limiting line is drawn where simultaneous isochrones intersect.

The forecast is refined by comparing the directions of movement of the rain shield and the dry air. If these differ by approximately 120°, the rain will stop abruptly at the convergence line. If the difference in the two directions is less, as in Figure 8, then deceleration of the rain shield is indicated, about 50% for this case. If the difference exceeds 120°, as in Figure 9, and the blocking anticyclone is intensifying, the rain shield will recede after reaching the convergence line.

References:


1. Durst, C.S., 1949: Meteorology of Airfields. London, His Majesty's Stationery Office. 88pp.

2. British Air Ministry Meteorological Office, 1952: Climatological Atlas of the British Isles. M.O. 488. 139pp.

3. Directorate of Weather, Headquarters Army Air Forces, 1942: Climate and Weather of the British Isles. U.S. Weather Bureau.

4. Kendrew, W.G., 1953: The Climates of the Continents. Oxford University Press, New York.

5. Byers, H.R., 1944: General Meteorology. McGraw-Hill, New York.

6. Petterssen, S., 1956: Weather Analysis and Forecasting. McGraw-Hill, New York.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NOTE: Observations and statistics are not available for this study.

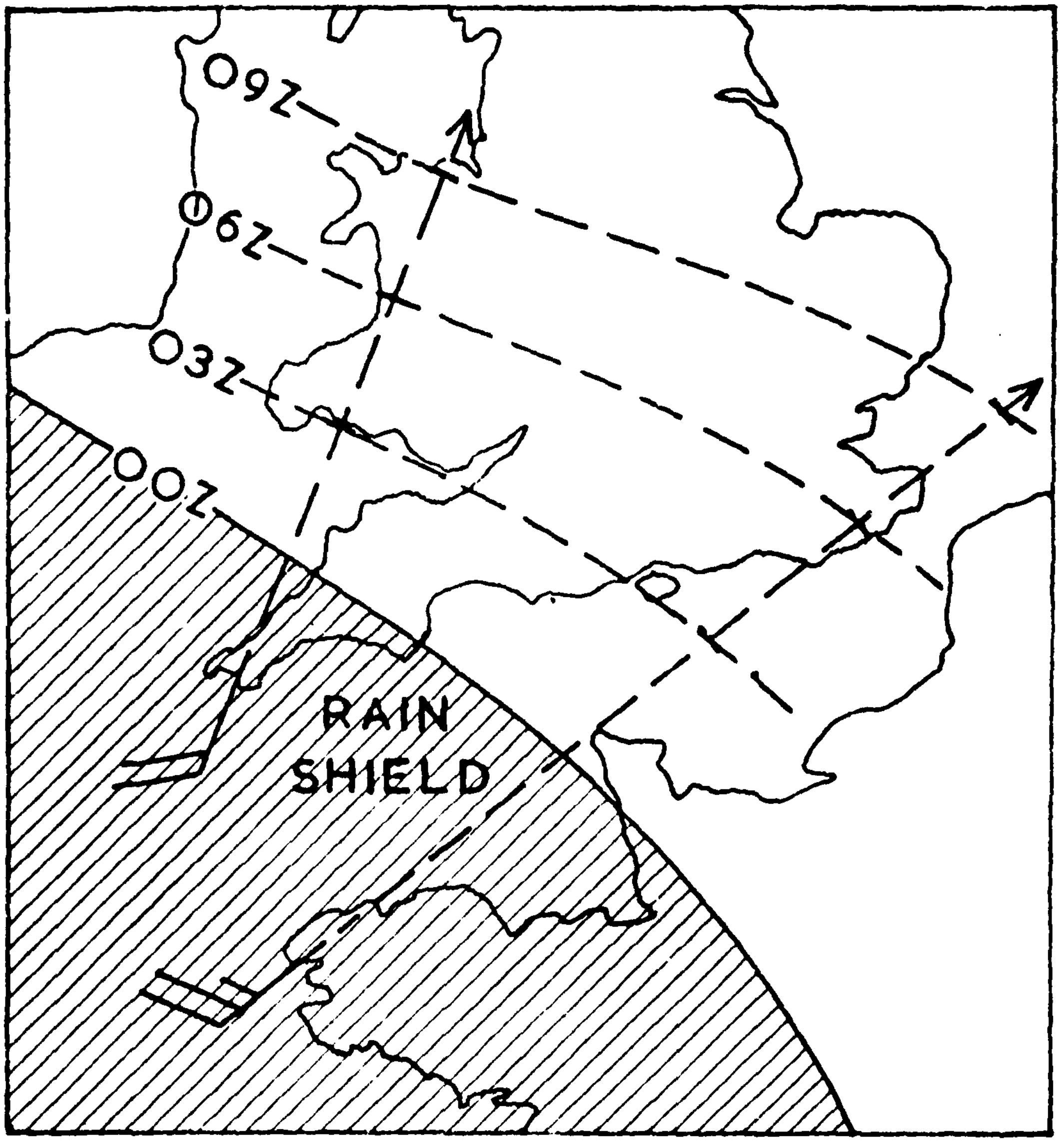



Figure 7. Normal advection of rain band with 700 mb winds, 9 March 19. The dashed curves are forecast isochrones, later verified, illustrating regular progression across England.

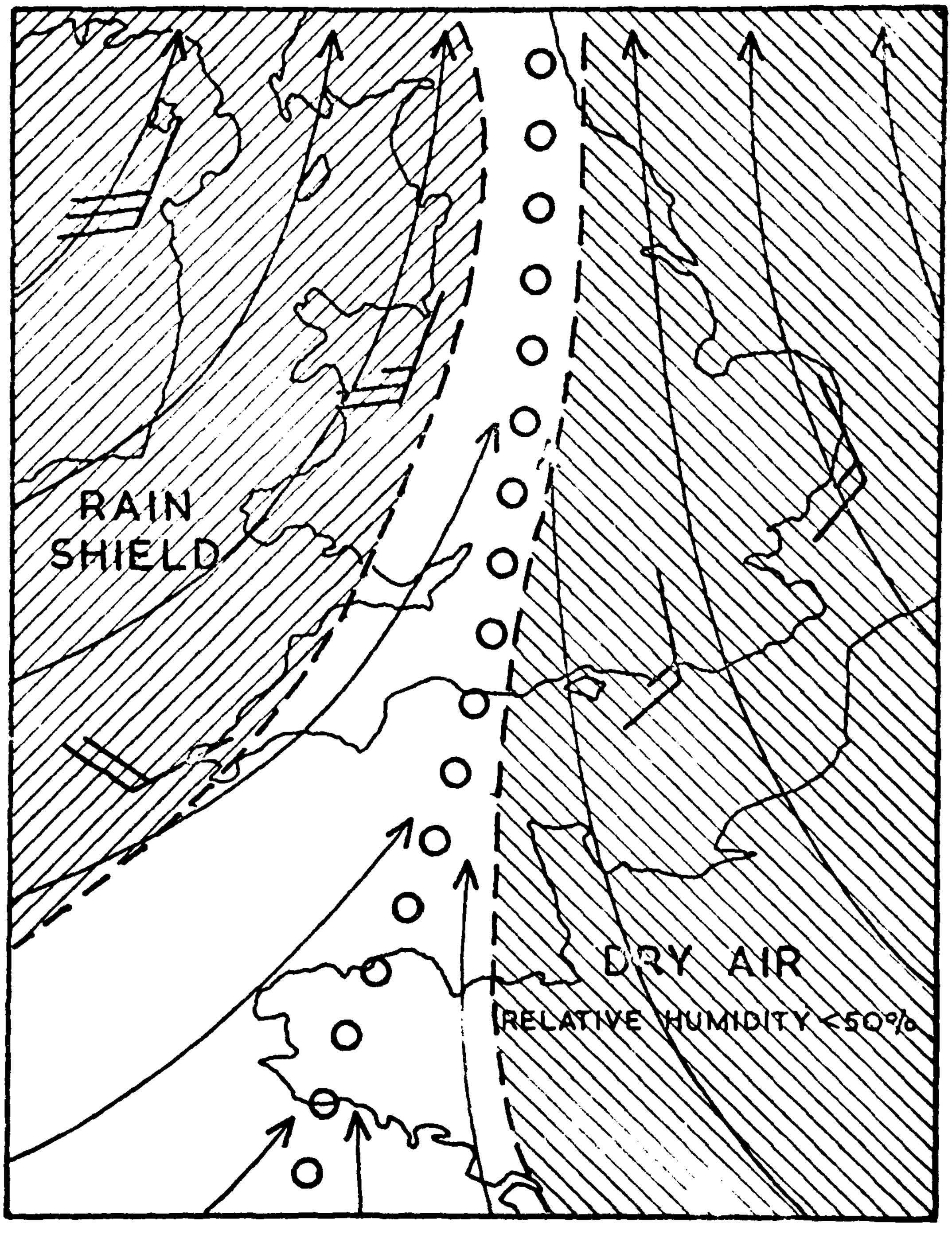



Figure 8. Rain shield superimposed on 700 mb streamline analysis, 0000 GCT 18 March 1960. The line of streamline convergence is marked by a line of circles and the area of dry air at 700 mb is shown.

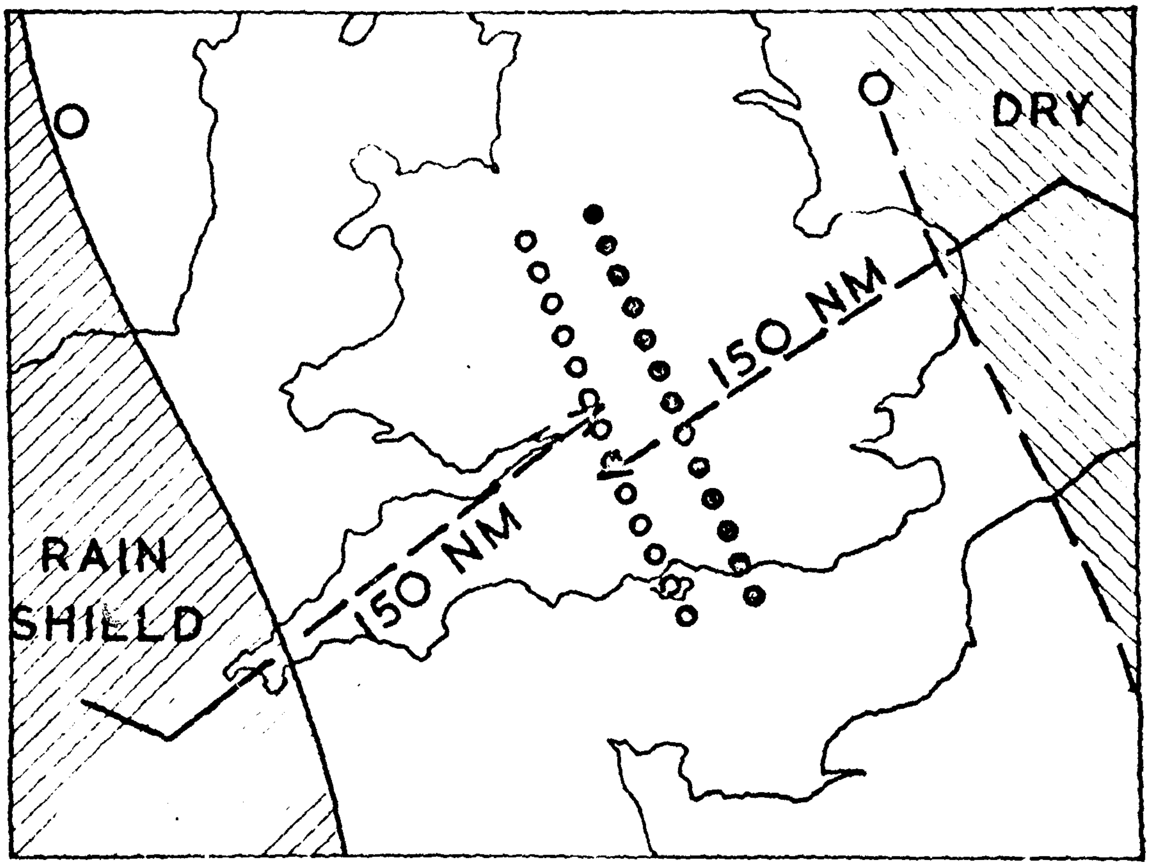



Figure 9. Forecast and actual limits of eastward penetration of the rain band 18-19 March 1960. The line of hollow circles was the forecast limit based on the 10-knot 700 mb winds reported by station 03808 on the southwest tip of England and station 03496 on the east coast. The line of solid dots was actually reached before retrogression began at 190600 GCT.

# SECTION IV

# WEATHER CONTROLS

AIR MASSES

Introduction

Before going into specific air masses and their effect upon the UK a brief review of air mass formation is called for.

1. An air mass is a large volume of air with approximately homogenious properties in the horizontal.

2. A given mass of air must remain in residence over a source region a sufficent time to allow the air to acquire the horizontally uniform and typical characteristics of an air mass.

3. Upon leaving the source region an air mass begins modification. The air mass begins to adopt the properties of the surface over which it is passing.

4. There are two major factors predominate in a source region, the physical properties of the surface and the prevailing low level circulation. Circulation is especially important. Air masses formed under anticyclonic systems tend to stretch horizontally; those formed under a cyclonic influence tend to shrink due to the cross-isobar flow. Also, in an anticyclonic system the air tends to become more or less uniform in the horizontal, whereas cyclonic systems usually maintain contrasts. As a final point, the subsidence of the anticyclones tends to lessen the lapse rate while the ascending motion due to convergence in cyclonic circulations steepens the lapse rate and, of course, increases the vorticity. Thus, regions of the globe dominated by semiparmanent high pressure systems, are especially favored as air mass source regions.

5. Several factors bear on the type of weather a given air mass brings. Whether an air mass is cold (k) or warm (w) relative to the underlying surface is a major factor. A cold air mass is likely to develop increasing instability due to heating from below, and is generally characterized by convective cloudiness, showers, and squalls. A warm air mass, on the other hand, tends to become increasingly stable and often exhibits persistent fog, stratus, and drizzle.

6. The trajectory followed by the air mass is also important, not only as pertains to the changing or air mass properties to reflect the underlying surface over which it passes, but also as relates to the dynamic nature of the trajectory. If the air follows a cyclonic trajectory, the lower layers tend to have steep lapse rates, and hence such an air mass will exhibit instability phenomena. An anticyclonic trajectory tends to enhance stability. Subsidence inversions tend to surpress any vertical developments stemming from the surface layer.

7. The [illegible] air masses of Europe are the mP and mT. The maritime influence of the North Atlantic and the Baltic and North Seas affect the United Kingdom's weather more than any other factor.

Maritime Polar (mP)

Maritime polar air is the most prevalent air mass affecting the UK. The characteristics of the air mass depend upon the source and the track it takes in reaching the UK. The prime characteristics of all mP air masses in winter are mild temperatures, high relative humidity, and general cloudiness. With cyclonic circulation the air mass will show noticable effects of mixing, convergence, and a steep lapse rate; during anticyclonic circulation the effects of subsidence and divergence tend to cause the air mass to have a more stable lapse rate.

The mP air masses originating in the Greenland-Spitzbergen area are cooler than normal in all seasons and unstable. This is brought about by its initial low temperature as arctic air and the comparatively short trajectory over open water. This mP air brings numerous showers especially on the windward coasts and over high elevations. In periods of stagnating fog and wide spread stratus becomes likely in autumn and winter.

Maritime polar air masses arriving from the west generally originated as continental polar (cP) over North America. As the cP moves out over the Atlantic Ocean it is modified to the properities of the underlying ocean surface. As a result this mP air mass is relatively warm, humid, and more stable than mP air masses arriving from the north of the UK. The temperatures tend to be mild in autumn and winter, with moderate temperatures in spring and summer. Its greater stability is associated with extensive fog and stratus during autumn and winter. During the summer months the stratus tends to have breaks over central UK.

Maritime Arctic (mA)

As the name implies maritime Arctic air originates over the Arctic Ocean. It is most often a winter phenomenon and most often observed over western Europe. When it does occur it is unseasonable cold during all seasons. Strong outbreaks of Arctic air are likely to occur following the passage of a deep low tracking through southern Scandinavia.

By the time the air mass reaches the UK it is very unstable, the instability is due to its passage over the warmer water surface. Weather associated with the Arctic air is usually showery. The majority of the showers occurring along the windward coasts, and higher elevations. The strength of the outbreak of Arctic air determines the occurrance and amount of showers occurring inland. Tops of CB's over the North Sea are generally low, around 20,000 feet, while inland they are at times even lower, 15-16,000 feet.

If the air mass stagnates, then there develops a high risk of fog during autumn and winter. Outbreaks of Arctic air during late spring brings the risk of a killing frost. In summer months mA air mass comes close to being identical with mP air. This is due to the longer trajectory it takes to reach the UK and the initial shallowness of mA air masses allows greater modification on the air mass.

Continental Polar (cP) and Continental Artic (cA)

These are cold, dry air masses that originate in the snow and ice fields of northern Russia and Finland. As a result of the predominant westerlies cP and cA air invades the UK only when a stationary high sets up over Scandinavia, producing an easterly flow over western Europe. The main characteristics of these air masses are their colder than normal temperatures and their initial fair weather. As mixing occurs over the North Sea showers may develop along the east coast. Once the air masses absorb sufficient moisture and mixing occurs persistent decks of stratocumulus tend to develop. During the summer months the influence of these air masses on the UK is rare.

Maritime Tropical

Maritime tropical air masses originate from the northern and eastern flanks of the Atlantic subtropical high pressure cells. Due to the distance the air mass must travel from its source region, it is subjected to considerable modification by the time it reaches the UK. Maritime tropical air reaching England is cooler, drier, and more stable than mT air masses affecting the southeastern U.S.. The strong subsidence found in the source region dries out the air mass through the vertical. During its advance the England mT air is cooler at the surface by the underlying surface, thus developing a strong low level inversion. Beneath the inversion mT air absorbs moisture from the surface thus increasing the moisture content of the lower levels. During the winter mT air reaches the UK with temperatures of 40-45°F and very high surface relative humidities. This results in frequent occurrences of prolong periods of low stratus, fog and drizzle owing to the pronounced low level stability. In thesummer months mT air is stable and warmer. Heating from below as the air moves over land tends to lessen the stability. Along the coasts and the English channel sea fogs are common, but inland, with a greater instability, the visibilities are generally improved. As a general rule windward areas will experience upslope and coastal fog, with occasional drizzle, during all seasons, while leeward areas will be brighter and sunnier.

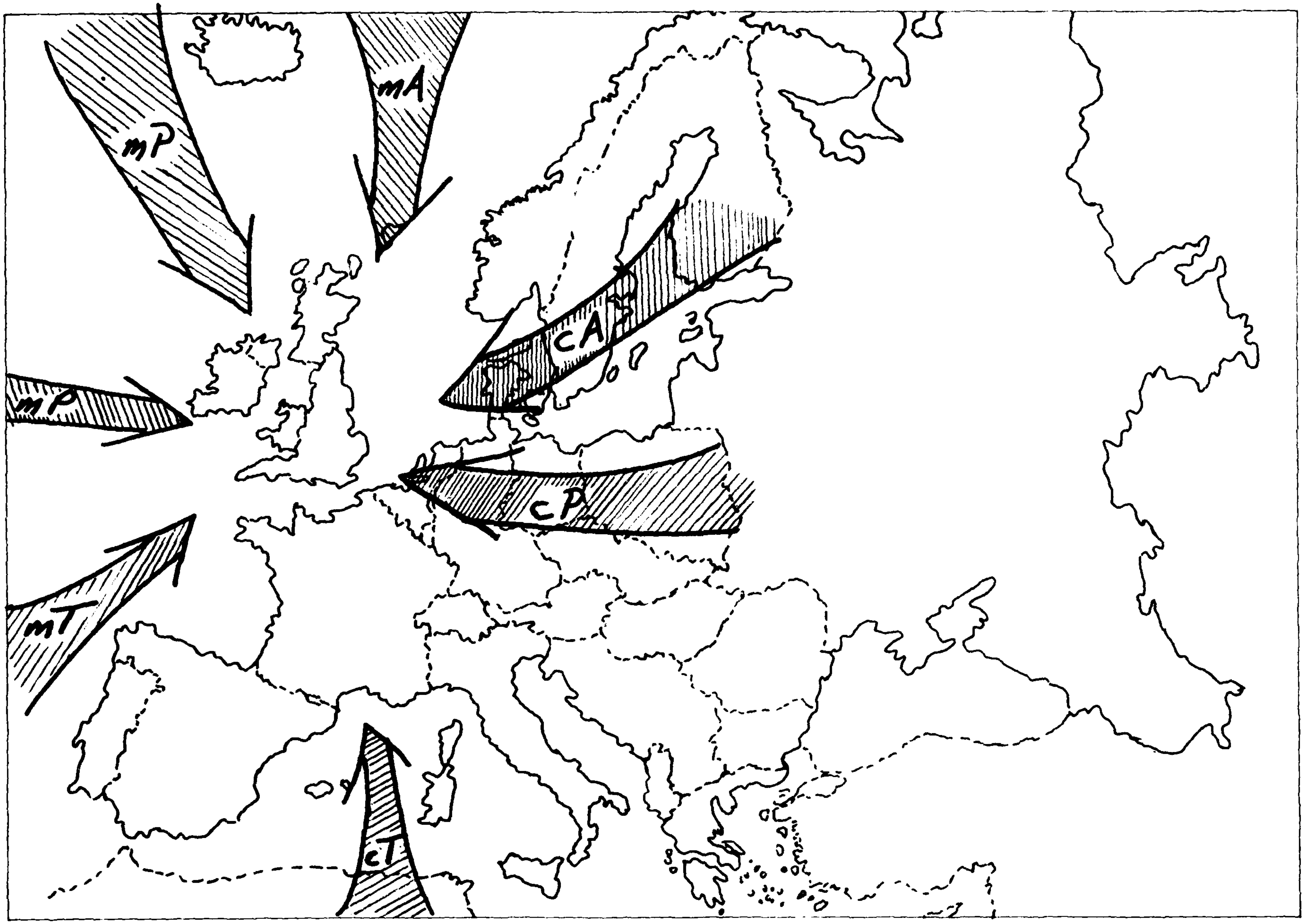



Figure 1  Air Mass Source Regions (From 2WWP 105-12)

## CYCLOGENESIS AND CYCLONIC PATHS

(FIG 2, 3)

It has been shown that most cyclones have a tendency to move northward after forming. The majority of deep cyclones stay north of 55N, although during winter and spring secondary tracks appear in southern UK.

The UK lies in a secondary axis of maximum cyclognesis which is between 49N and 57N most of the year. This area is most likely a result of breakoffs from the quasi-permanent subpolar lows.

The effects of terrain on cyclogenesis have little change with the season; however, the land/sea temperature difference does have a major effect on cyclogenesis and has significant change from season to season.

### WINTER

In the winter the land/sea temperature difference is at its greatest, with the warmer water areas a favorite area of cyclogenesis. There is a greater frequency of activity over the North Atlantic, with two centers of cyclogenesis near Iceland.

These centers are the beginning of the primary track which goes north of 60N through the Norweigian Sea into the Artic Ocean. There is also a secondary track along 60N through Scotland into the Baltic Sea.

During this period, the Irish Sea and the English Channel become sites of frequent cyclogenesis. From here a secondary track is created SE across France into the Mediterranean Sea.

Towards winter's end there is a general decrease in the frequency of cyclogenesis over most of Europe.

### SPRING

As land areas begin to warm the shift of cyclogenesis from the water to the land begins. During May thermal lows begin to appear and the axis of cyclogenesis shifts southward to 45-50N.

The primary path of cyclones moves south extending across northern Scotland into southern Scandinavia. The path through the Norwegian Sea becomes a secondary path. During spring blocking highs reach their peak of activity and create a secondary path across southern UK into the Baltic Sea. During this time, southern UK receives its maximum of cyclonic activity.

### SUMMER

With the land being the warmer it now becomes the center of cyclogenesis. The main axis of cyclogenesis extends from Spain across Europe into the Urals.

Storm tracks favor land areas due to the increase in surface heating, as a result a secondary track develops west of Ireland in a SW to NE orientation. As summer progresses this route moves to lie over Ireland.

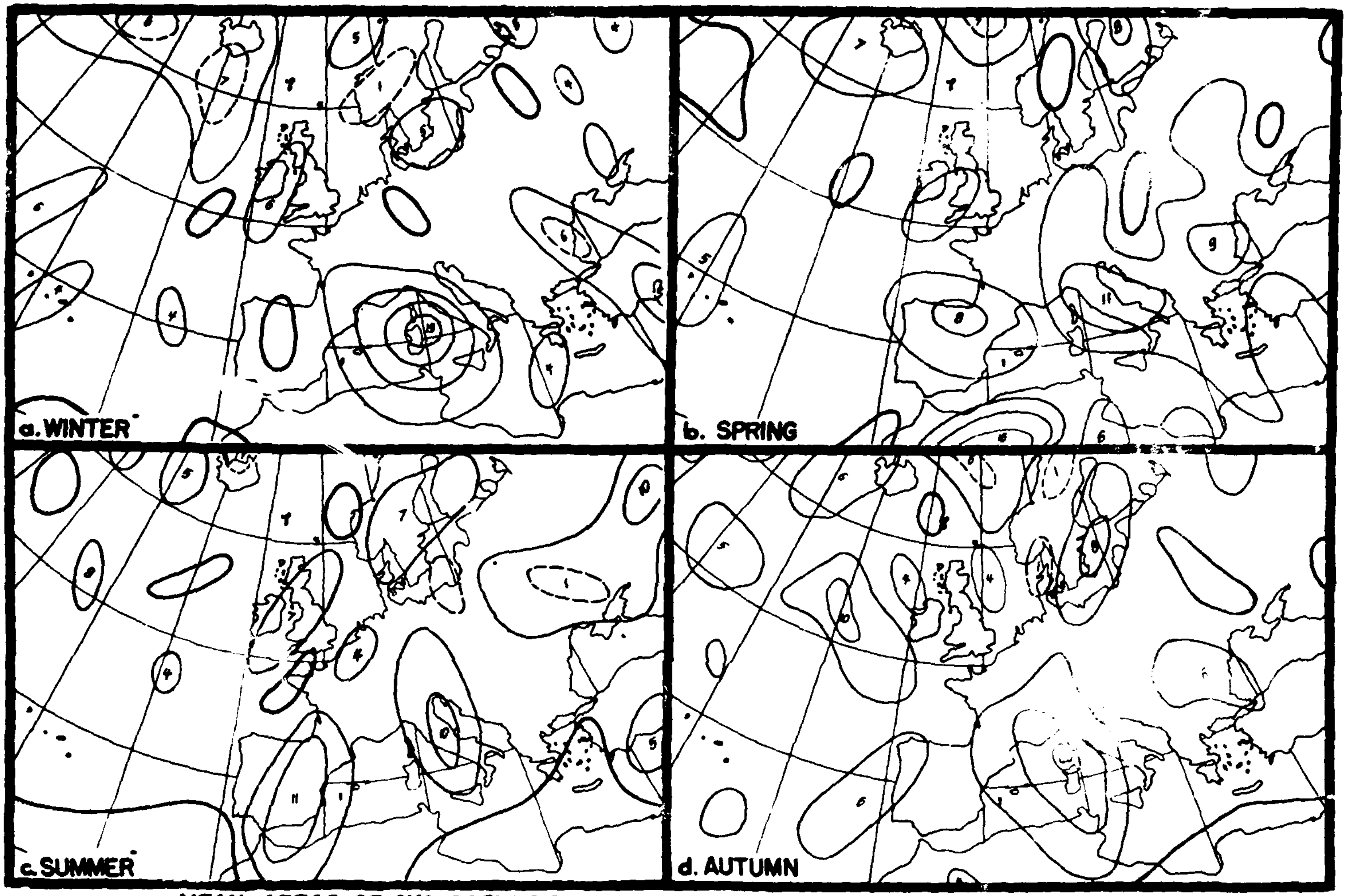
The British Isles has an increase of activity which accompanies an increase in the upper level wind speed during mid-summer. Storm tracks move further north and those in central Europe disappear, the exception is the 60N track of Scotland to the Baltic which remains constant.

During August the storm tracks across the eastern Atlantic become more zonal. As a result the cyclogenesis pattern over the North Atlantic becomes disorganized.

AUTUMN

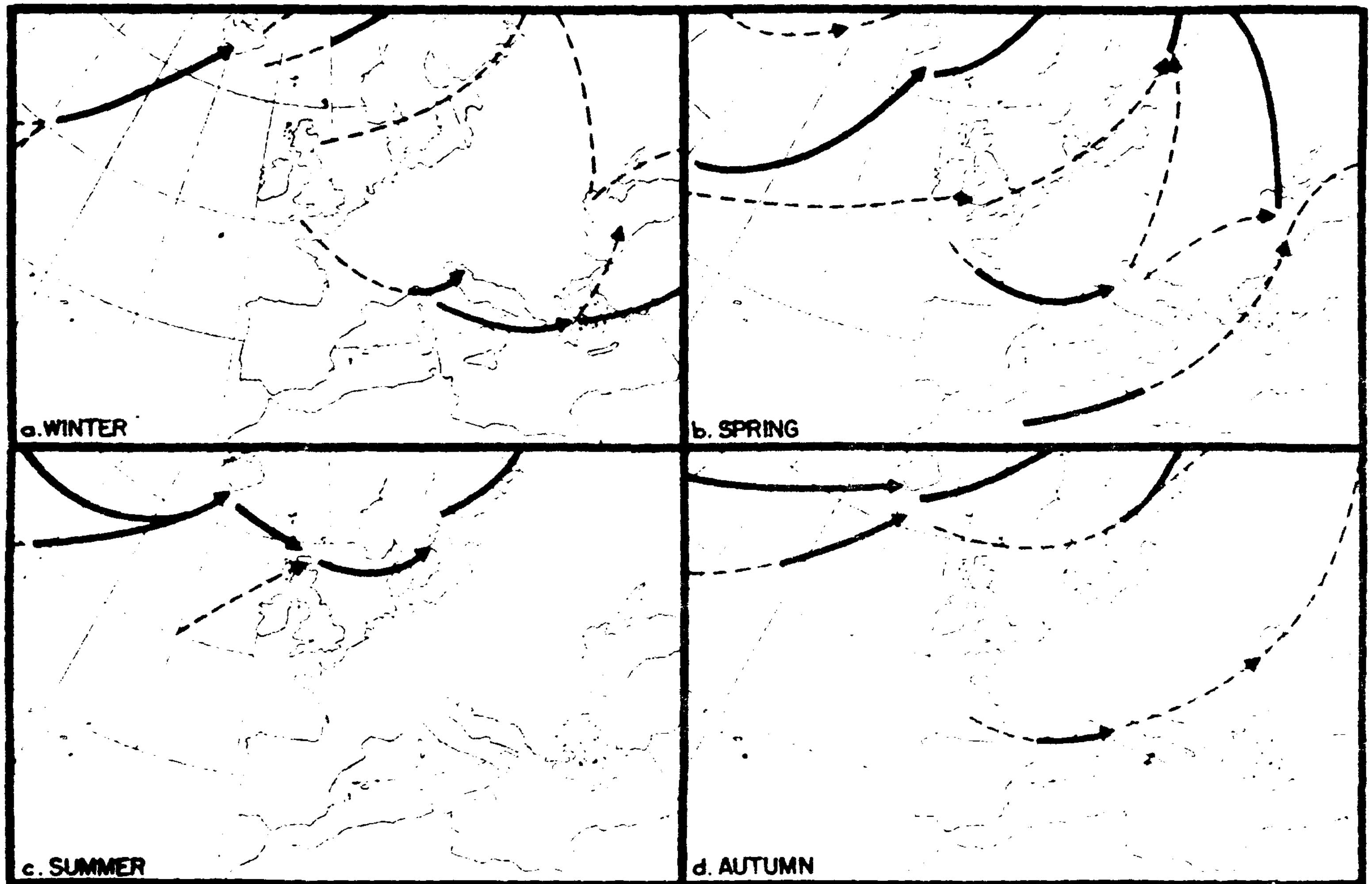
Like spring, autumn is a transition period. Early autumn continues to have summer characteristics while late autumn has winter characteristics. There is a gradual change in the land/sea temperature difference as the sea again becomes the warmer. The storm tracks and area of cyclogenesis begin to move back over water areas.

The primary track begins its movement back up into the Norwegian Sea and the 60N track becomes a secondary. The secondary track over Ireland continues to move east and lies over southern UK before disappearing. During November an area of cyclogenesis develops in the Brest region of France and continues there thru the winter. This is source region of the storm track SE across France into the Mediterranean Sea.




MEAN AREAS OF CYCLOGENESIS BY SEASON. HEAVY LINE ENCLOSES AREAS OF NO OCCURRENCE.
(From 2WWP 105-12)

Figure 2




MEAN PATHS OF CYCLONES BY SEASON. PRIMARY TRACK; SECONDARY TRACK

(From 2WWP 105-12)

**Figure 3**

## ANTICYCLOGENESIS AND ANTICLONIC PATHS

(FIG 4 , 5 )

The principle axis of anticyclogenesis is located near 45N most of the year. This axis is furthest north during August and is furthest south during January.

In comparing the primary axis of genesis and the primary track of movement it is found that there is little meridional displacement of either axis or track.

Anticyclones favor the cooler of the land/sea temperature difference. They favor the land during the winter and the water areas during the summer.

### WINTER

During winter there is a high frequency of anti cyclogenesis over land. Break-offs from the Azores High account for most of the anticyclogenesis over the North Atlantic. Of interest to the UK forecaster is that most of these break-offs enter Western Eurpoe on a primary track of 50N. The anticyclones entering along this track undergo reinforced anticyclogenesis in France. France generally has five anticyclogenesis per 30 day period.

Migratory anticyclones are primarily of two types:

a. Those which originate in the middle latitude and move mainly eastward.

b. Those which originate at high latitudes and usually move southward.

Some of the latter originate in Scandinavia but the majority are from Alaska or NW Canada.

### SPRING

The effects of increased heating over the continent begin to effect the regions of anticyclogenesis. Centers of activity shift from the warming land to the cooler water bodies. Activity over land continues to decrease and the primary tracks over land disappear.

By late spring the shift of the areas of anticyclogenesis to the ocean is complete. The primary track for highs is still 50N, but they now move up thru the English Channel. A secondary path appears from Iceland southest across the Irish Sea and southern UK.

### SUMMER

Centers of genesis have shifted to over water bodies. The northward shift of the Azores High accounts for some of the activity over the North Atlantic.

The primary track continues to exist in the vicinity of 50N thru the English Channel. The secondary track begining around Iceland has moved over to the North Sea.

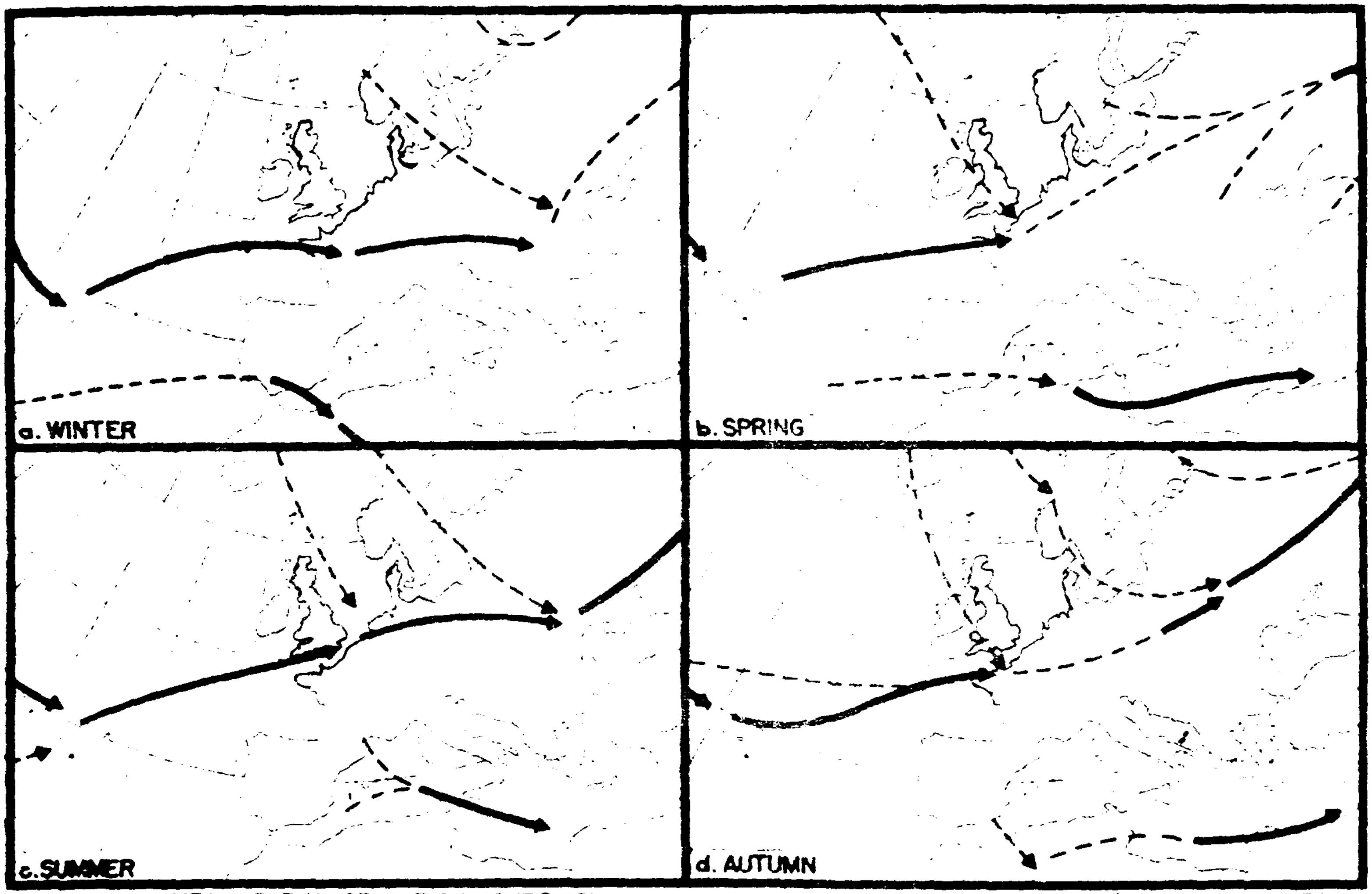
During the summer the English Channel and the Bay of Biscay become centers of anticyclonic activity.

Toward the end of summer the continued warming of the water with little additional warming of the land results in a decrease of the land/sea temperature difference. This brings about a decrease in anticyclogenesis. The Azores High continues to stimulate further genesis over France and Germany.

AUTUMN

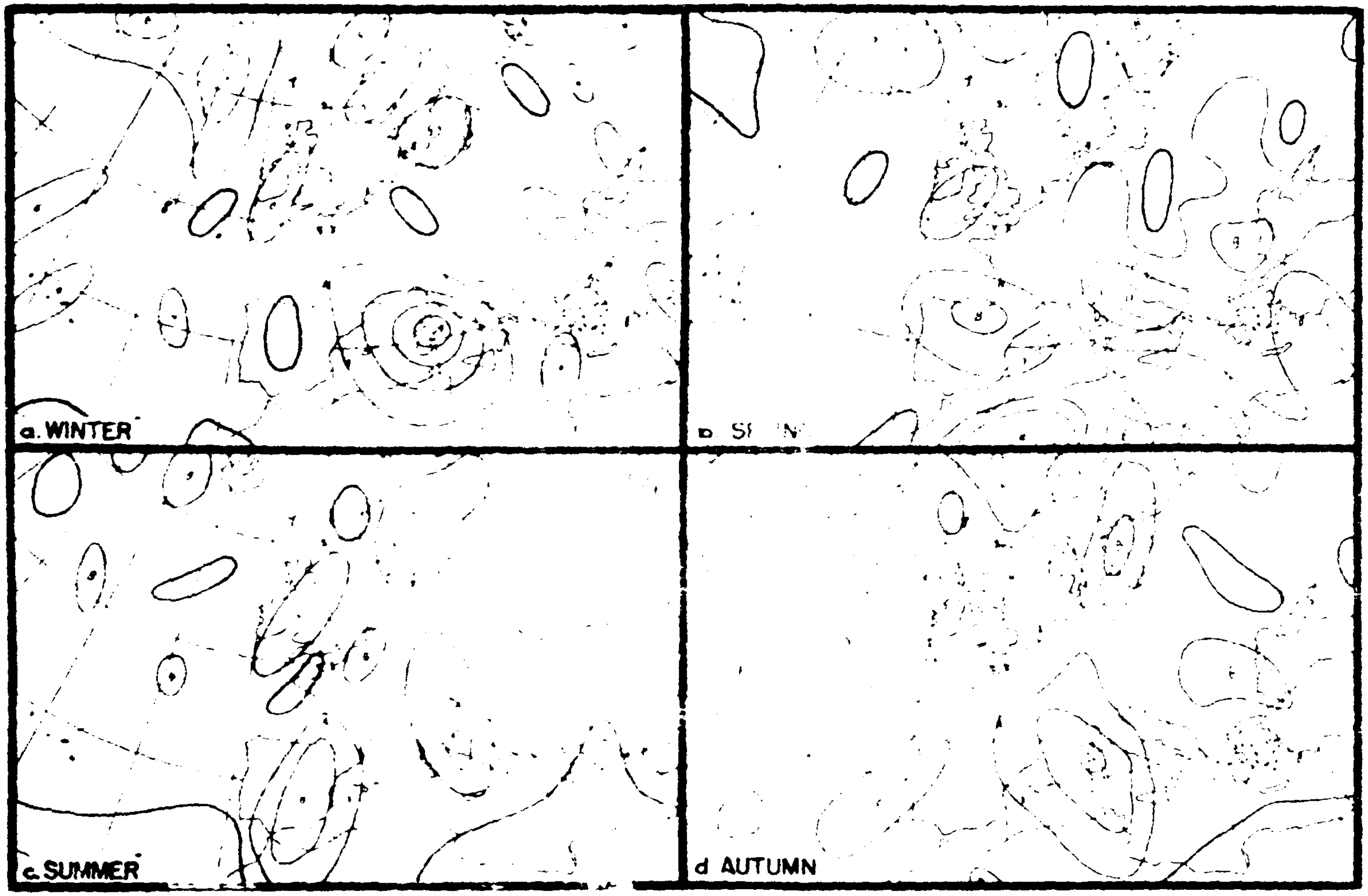
Autumn is a transition period with the reverse cycle of spring. The shift of genesis is to the land masses combined with a southward shift of the axis of anticyclogenesis.

Like the past seasons the primary track is still in the vicinity of 50N. The primary track though is shifting back to the land areas, going thru France and Germany. The secondary path moves back to the west of England.




MEAN PATHS OF ANTICYCLONES BY SEASON. PRIMARY TRACK; SECONDARY TRACK.
(From 2WWP 105-12)

Figure 4




MEAN AREAS OF CYCLOGENESIS BY SEASON. HEAVY LINE ENCLOSES AREAS OF NO OCCURRENCE.
(From 2WWP [illegible]-12)

Figure 5

forecasters

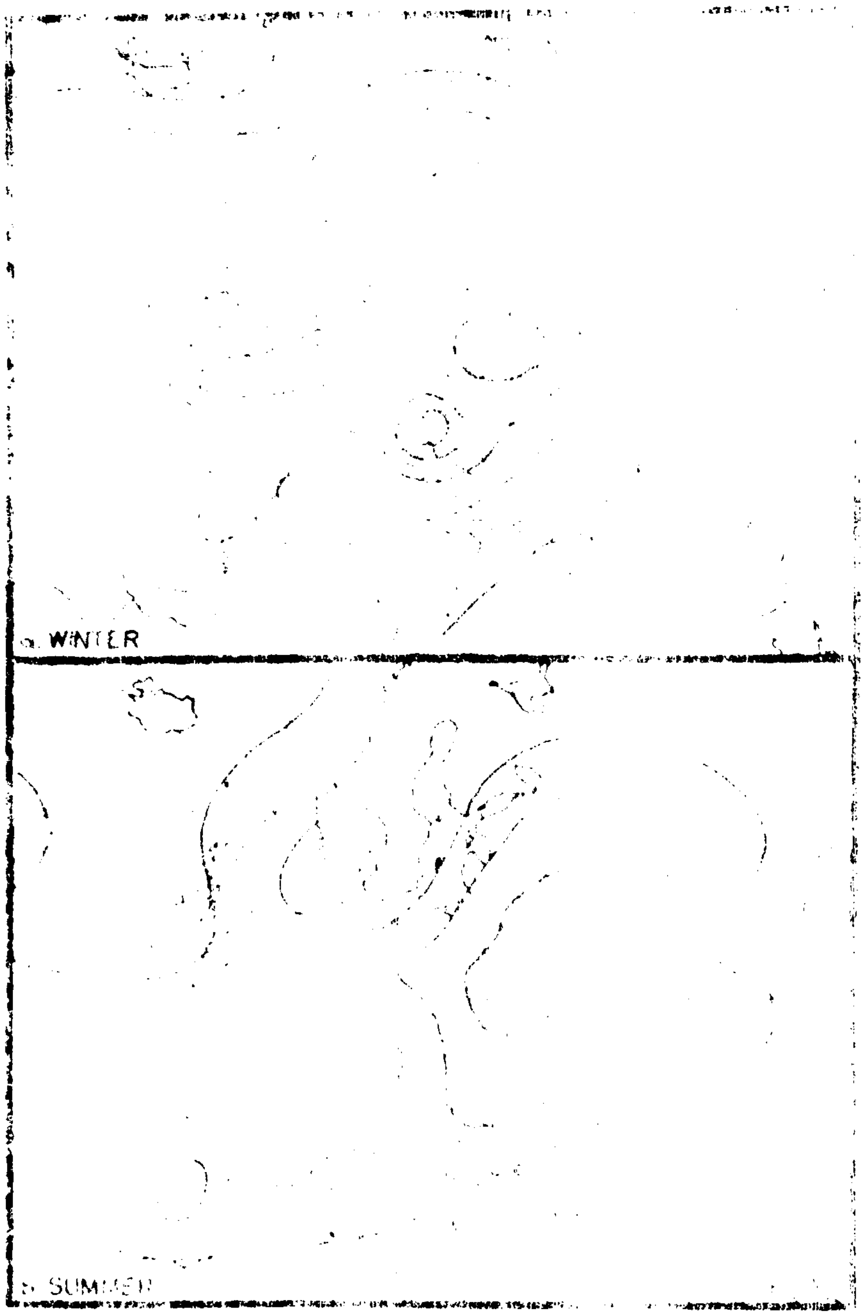
1

running against a cold high sitting over Europe.

* Samson, H.W.;"A Study of Cold Fronts Over the British Isles", Q.J.R. Met Soc, London, 77 1951, pp 96-120

| FEATURES | ACTIVE (ANA-) COLD FRONTS | INACTIVE (KATA-) COLD FRONTS |
|---|---|---|
| Temperature | Often a large fall which may be sudden--mean temperature drop 3°C. | Changes may be very slight and gradual--mean temperature drop 1°C. |
| Relative Humidity | High and changes little. | Decreases and the fall may be of considerable magnitude and quite sharp. |
| Clouds | Low clouds tend to clear at frontal passage. High clouds often extend to 100 mi. behind front. | Frontal clouds have little vertical extent often not exceeding 10,000 ft, any clouds above that are usually thin and patchy. There is rapid clearance at frontal passage. |
| Precipitation | Generally fairly heavy rain at frontal passage with steady lighter rain after passage, sometimes up to 2-3 hours. An average precip amount of 0.25 per frontal passage has been found to occur. | Amounts generally very light and frequently mild. The precip amounted to only 0.04 on an average and fell immediately before or during the frontal passage. There was very little post frontal rain. |
| Wind | Usually a sharp veer accompanied by a sharp decrease in wind speed. | Wind veer may be very gradual and speed changes usually slight. |
| Average 700MB wind veer at frontal passage | 23° | 15° |
| Average 500MB wind veer at frontal passage | 15° | 5° |

TABLE 1 - Frontal Characteristics at Frontal Passage




[illegible] ANTICYCLONIC [illegible]
(From 2WWP 105-12)

Figure 6

## BLOCKING HIGHS

Across the North Atlantic and most of Europe the westerly flow at the 500MB level is strongly zonal. Not infrequently, however, this zonal flow is terminated, and a cellular pattern substituted. A quasi-stationary high in the eastern North Atlantic, in the vicinity of 5°W - 15°E, splits the westerlies into two branches so that a double jet stream results. One branch flows northward (75-80°N) around the blocking high and the other southward (36°N). There is a distinct seasonal preference for blocking activity, with a minimum from June to November and a primary minimum in July-September. The maximum is in April, while December to May is the general period of most frequent blocking. During the period of maximum activity 30 - 40% of the days are affected by anticyclonic blocking, while during the minimum it is under 20%.

As one might expect, the blocking action of the warm high and the resulting splitting of the jet stream cause a dislocation of the routes of traveling disturbances. The general effect is to reduce the number of activity centers moving eastward in the vicinity of 50 - 55°N and to concentrate them to the north and to the south of those more central latitudes of Europe, in the vicinity of the northern and southern jets. Thus, one main route of disturbances lies well to the north of Iceland and is associated with the branch of the jet following a course around the northern side of the blocking high, a second track follows the southern jet into the Mediterranean latitudes.

The effects of the blocking action are felt often enough so that they appear to leave their imprint upon the general pattern of disturbance routes in Europe. Considering all cyclones with central pressure less than 1013 MB, it can be noted that the two areas of concentration are:

a. Across Scotland and Scandinavia

b. Along the axis of the Mediterranean Sea

the two positions of the jet at the time of the blocking activity. By contrast, the area with a minimum of cyclonic activity is in the general vicinity of 50N latitude where the blocking high tends to obstruct the eastward advance of Atlantic cyclones. Deep cyclones in winter are concentrated to the north of 55°N and in the central Mediterranean, with a minimum of activity in the vicinith of 50°N. In the summer, deep cyclones disappear from the Mediterranean and there is a distinct concentration north of 55°N.

Important effects of blocking action upon weather and climate are to be expected. It was found that during a period of winter blocking action a tongue of positive temperature anomalies coincides with the western and northern margins of the blocking high where a strengthened SW flow prevails (Figure 6 a). Most of Scandinavia and the whole North Atlantic between Greenland and Scandinavia, on such occasions, may be warmer than normal. Negative temperature anomalies are concentrated to the rear of the blocking high where cold CP surface air, following the path of the northern jet, moves southward into a well-developed pressure trough which is quite evident at the 500 MB level. The

trough and its polar air are very prominent in the vicinity of 50°N. On occasions of winter blocking, the strongest negative anomalies of temperature are to be found in an east - west belt along 50°N latitude that extends from SW USSR across Europe and into southern England.

Summer blocking appears to produce effects upon temperature distribution in Europe similiar to those of winter. The UK is characterized by a negative mid-troposphere trough of low pressure lying eastward of the blocking warm high that tends to channel cool northerly air south over the UK. (FIGURE 6 b)

In summary, the absence of a blocking high and the existence of a strong zonal flow of westerly air with a single jet stream result in stronger positive anomalies over the UK, especially in winter, and precipitation amounts are above normal. With a blocking high over or west of the UK, temperatures and precipitation are below normal, except in local areas. It can be expected, then, that variations in the frequency of blocking activity will be reflected in the variable seasonal weather from one year to another.

It appears that the frequent blocking action may contribute to an understanding of some of the temperature peculiarities of Europe. The fact that isolines of winter temperature anomaly have a distinct SW-NE trend south of about 55°N suggests the effect of the northern invasions of cold air east of the blocking high.

In the summer the near absence of significant temperature anomalies over most of Europe suggests that the continent does not warm up in summer to the degree that one might expect. This may be interpreted as being due in part to the cool air from the north entering on east side of theblocking high. To be sure, summer and fall are the seasons of only minimum blocking highs, and maximum zonal flow, so that the effects of blocking action upon summer temperature characteristics are subordinate to those of the stronger zonal flow.

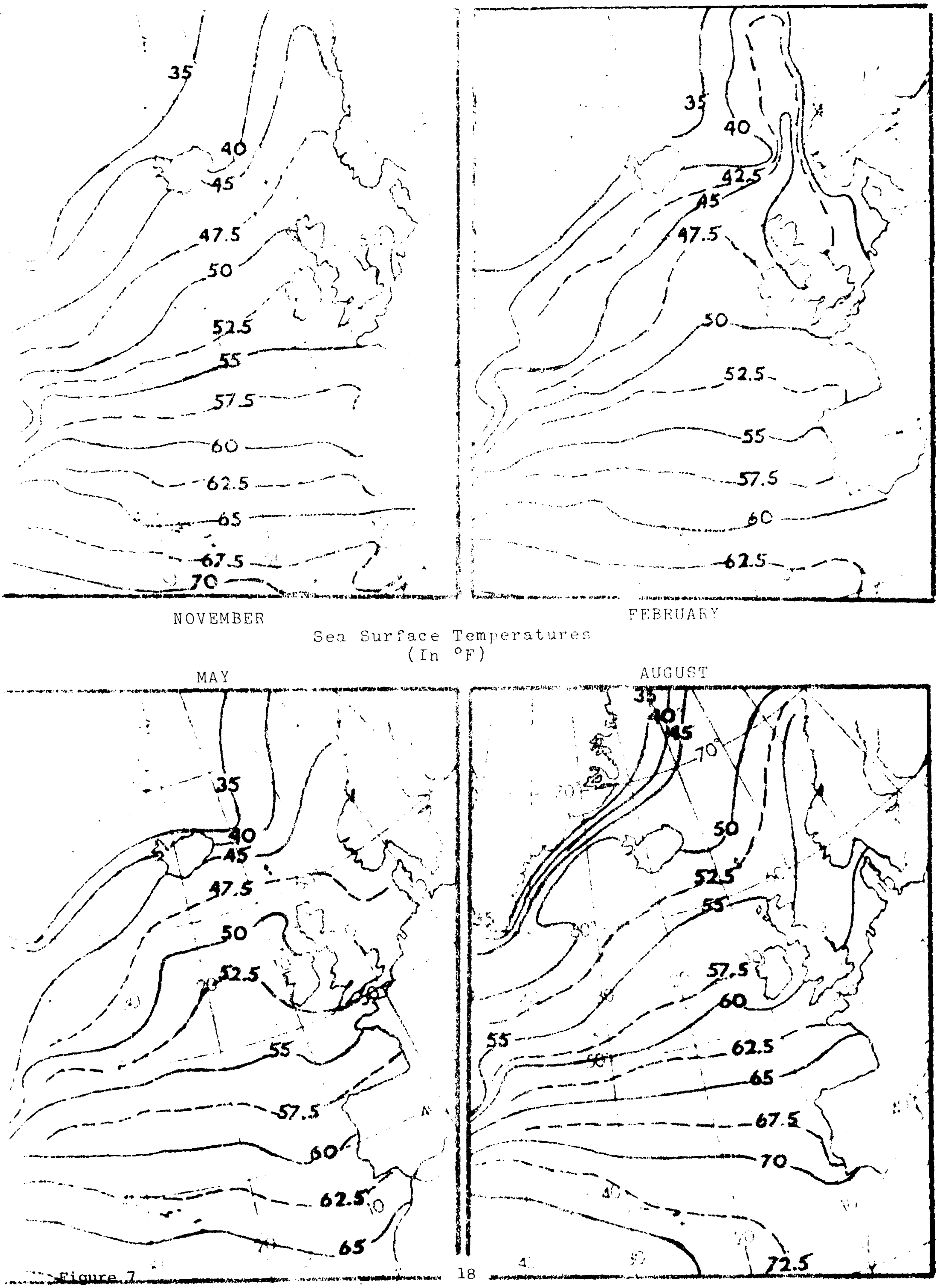

35
40
45
47.5
50
52.5
55
57.5
60
62.5
65
67.5
70
NOVEMBER
35
40
42.5
45
47.5
50
52.5
55
57.5
60
62.5
FEBRUARY
Sea Surface Temperatures
(In °F)
MAY
35
40
45
47.5
50
52.5
55
57.5
60
62.5
65
AUGUST
35
40
45
50
52.5
55
57.5
60
62.5
65
67.5
70
72.5

Figure 7

## SEVERE WEATHER IN UNITED KINGDOM

### 1. Thunderstorms

a. Considering the northern location of the British Isles, it has its fair share of thunderstorms (Figure 8 ). Like the rest of the Northern Hemisphere, most thunderstorms in the United Kingdom occur from May through mid September.

b. For its size, the United Kingdom has a considerable shift in thunderstorm activity during the year. During the winter, the maximum activity occurs along the western shores. While during the spring, the shift in activity occurs along Anglia and southeastern England. The Midlands and the area northeast of it are favored during the summer months. Autumn, on the other hand, has an even distribution of storms throughout the country.

c. There is a high ratio of cumulonimbus to that of actual thunder. In general thunderstorms do not last long. Many only have a couple of peels of thunder. In the winter, the average thunderstorm length is twenty minutes. Summer thunderstorms are longer with an average length of fifty minutes.

d. The maximum occurrence of thunder is generally around 1500L with a minimum of activity at 0700L.

e. Nocturnal thunderstorm activity at Fairford is hindered by the orientation of the surrounding ridges. These hills cut off the low level warm, moist air needed to sustain thunderstorms during the evenings.

f. Winter thunderstorms are usually associated with intense cold pools showing up at the 500 MB level. Winter storms have a tendency to dissipate near sunset with the loss of heating. The tops of storms during winter are generally low with an average height of 17,000-20,000 feet. Summer thunderstorms are generated by numerous means, e.g., cold pools, fronts, unstable airmass, etc. Tops of storms are considerably higher during the summer with an average of 25,000 feet and occasionally exceeding 30,000 feet . Even though considerably smaller than their stateside cousins all potential hazards still exist.

### 2. Hail

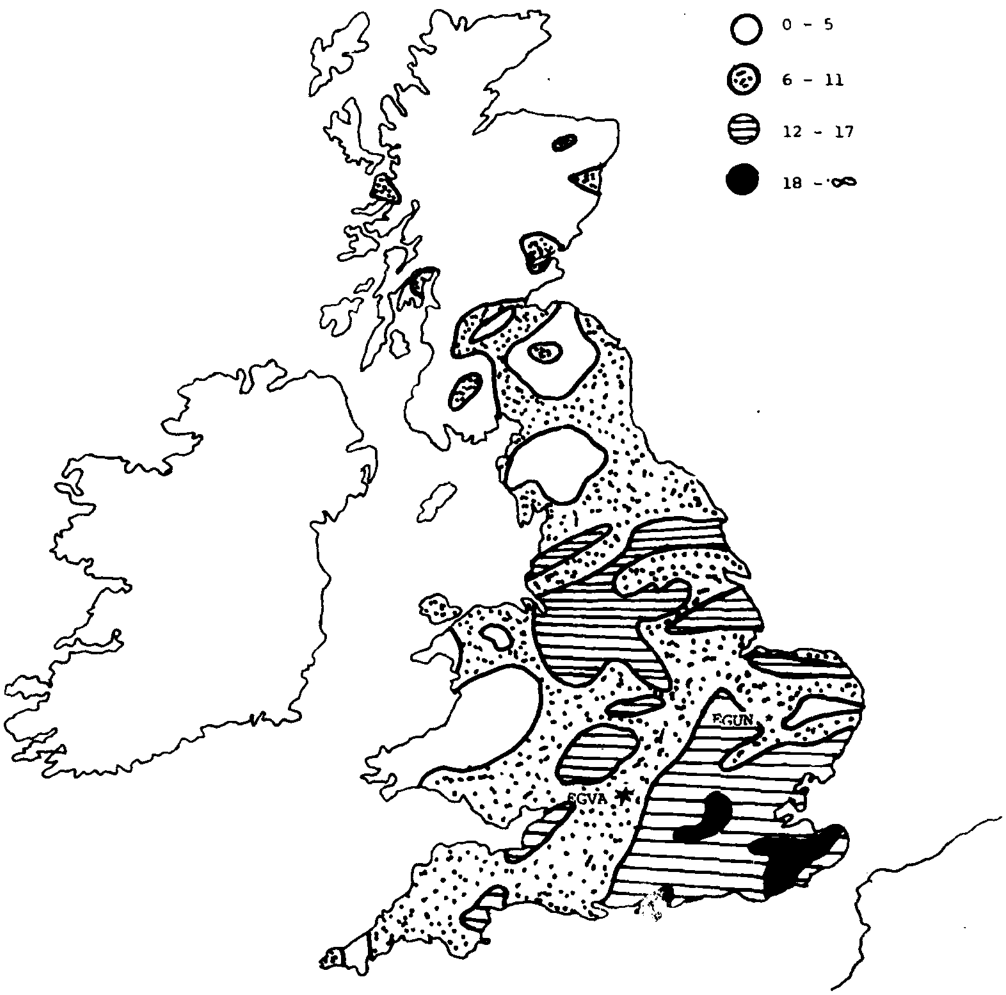
Small hail is common year around; although, it occurs more often in winter and early spring in conjunction with strong cold pools showing up at 500 MB. Large hail is rare. Between 1906 and 1955 there have been approximately 170 damaging hailstorms reported in the entire United Kingdom.

### 3. Wind

Gradient winds of greater than 35 knots are common from mid September through early May. Strong, purely convective winds associated with thunderstorms and rainshowers are rare. Most of the strong winds associated with convective activity is associated with the forcing to the surface of stronger winds aloft, rather than convective down rushes.

4. Tornadoes

Tornadoes or whirlwinds, as they are commonly called in the UK, are not as rare as normally thought. They occur mostly in the spring and early summer. But when they do occur they usually lack the destructive power of their cousins in the States. Like hail they are generally associated with a strong cold pool appearing at 500 MB.




ANNUAL TSTM ACTIVITY IN THE U.K.

Figure 8

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